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Boston Transit Commission

Second Annual Report

August 15, 1646.

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SECOND ANNUAL REPORT

OF THE

BOSTON-TRANSIT COMMISSION,

FOR THE YEAR ENDING

AUGUST 15, 1896.

FROM

THE BOSTON TRANSIT COMMISSION,

20 Beacon Street.

GEORGE G. CROCKER, *Chairman*,

CHARLES H. DALTON, GEORGE F. SWAIN,

THOS. J GARGAN, ALBERT C. BURRAGE,

Commissioners.

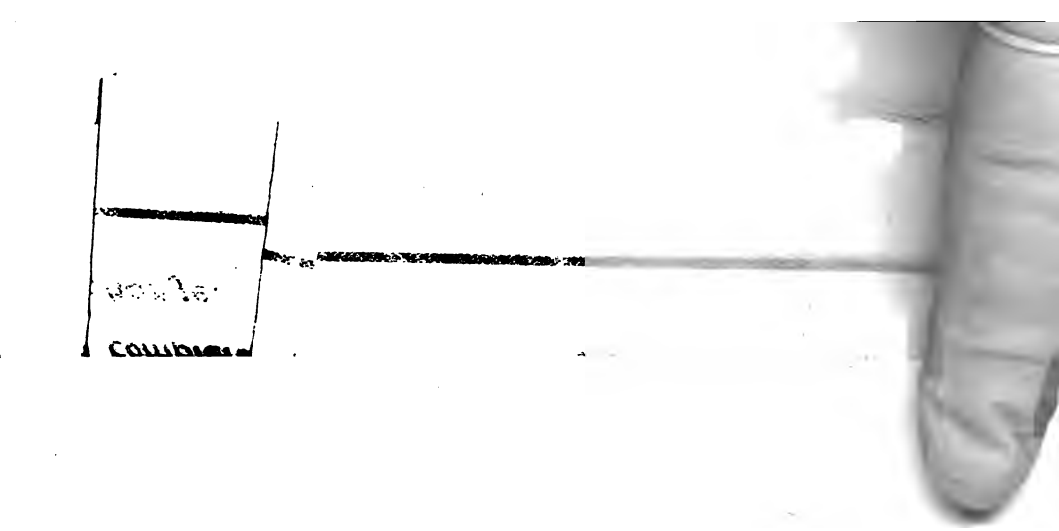
HOWARD A. CARSON, *Chief Engineer.*

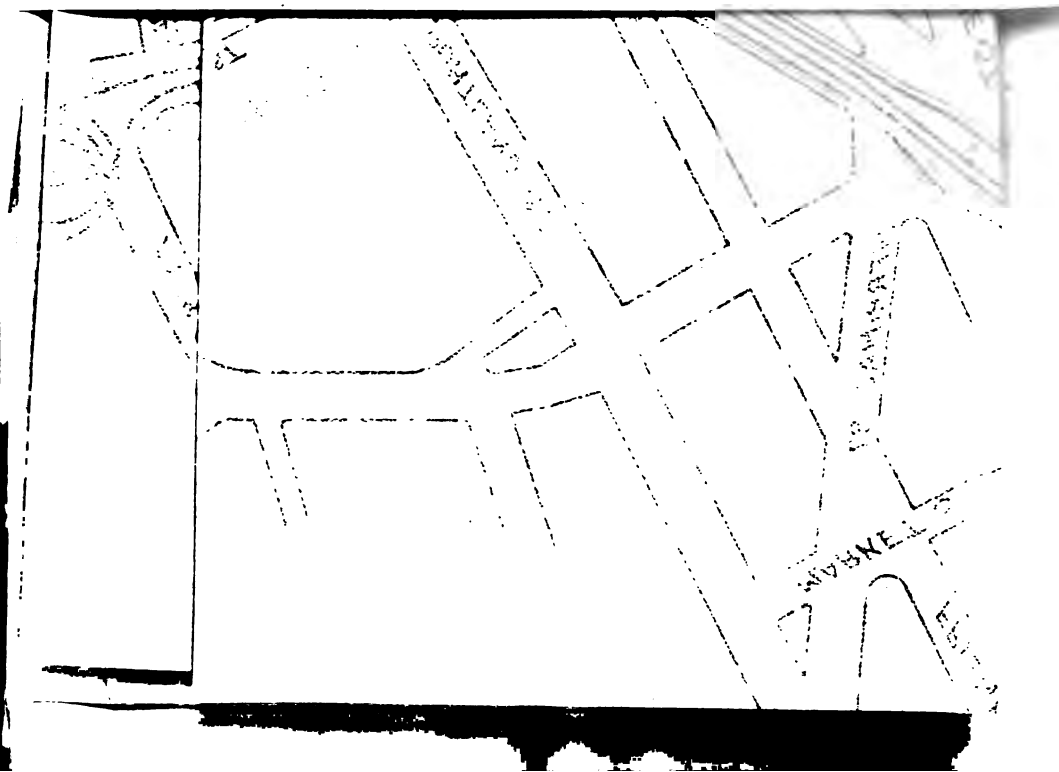
B. LEIGHTON BEAL, *Secretary.*

BOSTON:

ROCKWELL AND CHURCHILL, CITY PRINTERS.

1896.





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1896.

DEPARTMENT OF
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HARVARD UNIVERSITY
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BOSTON TRANSIT COMMISSION.

20 Beacon Street,
Boston, August 15, 1896.

To the City Council of the City of Boston:

In compliance with Statutes of 1894, chapter 548, section 24, the report of the Boston Transit Commission for the year ending August 15, 1896, is respectfully submitted.

The Subway.

As appears from the annexed report of the Chief Engineer, Mr. Howard A. Carson, the work on the subway has progressed during the year in a satisfactory manner. Novel in method and character as the work has been, no serious unexpected difficulties have been encountered. Several of the contractors have failed to complete their portions of the work within the times specified in their contracts, but the delays thus far suffered will not materially postpone the completion of the whole work. The Metropolitan Construction Company, in building that portion of the subway under Tremont street from Boylston street south to the vicinity of Hollis street, deserves honorable mention for having thus far kept fully up to the estimated amount of progress necessary to enable it to finish its work, under the contract, at the required time.

Injunction Proceedings.

An account of legal proceedings which were instituted for the purpose of enjoining the Commission from carrying on the construction of the subway was given in the first annual report, as far as they had then progressed.

When that report was submitted, the bill in equity, asking for an injunction against the Commission, brought by Hon. Thomas N. Hart, Hon. F. O. Prince, and others, had been heard by Mr. Justice Knowlton of the Supreme Judicial Court, upon a motion for a preliminary injunction. This preliminary injunction the Court refused to grant.

After several amendments to the bill had been made by

the complainants, and a demurrer had been filed by the respondents, there was a hearing upon the bill and demurrer before Mr. Justice Morton of the Supreme Judicial Court in February, 1896. The demurrer of the respondents was sustained, and the case was reported to the full court. It was argued before the Supreme Judicial Court for the Commonwealth in March, 1896, Messrs. Francis A. Brooks and John D. Bryant appearing for the complainants and Mr. Solomon Lincoln for the respondents. The city of Boston was represented by Mr. Thomas M. Babson, the City Solicitor.

On June 15, 1896, the Supreme Judicial Court for the Commonwealth sustained the demurrer of the respondents, in an opinion written by Mr. Justice Allen, and ordered the bill to be dismissed. Such an entry was made on the docket, and these legal proceedings thus ended.

A copy of the opinion will be found in the Appendix.

Legislation of 1896.

A law has been passed this year entitled "An Act relative to the Construction of Subways in the City of Boston" (Acts of 1896, chapter 492), by which the term of the contract which the Commission is authorized to make for locations for tracks in the subway, and for the use thereof by any street-railway company or companies, has been limited to twenty years instead of fifty years, the limit named in Acts of 1894, chapter 548, section 35.

A proposition to further amend the subway acts by forbidding the Commission to make a contract with any street-railway company for the exclusive use of the subway failed to become a law. Pending the consideration of the proposition to limit the term of any contract, and to forbid the making of any contract for the exclusive use of the subway, the following answer was given by the Commission to an inquiry made by Hon. Charles F. Sprague of the Senate:

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, May 16, 1896.

HON. CHARLES F. SPRAGUE:

MY DEAR SIR: You have asked me for the views of this Commission in relation to the two bills soon to be considered by the Senate relating to the subway.

The first bill limits the term of any contract for the use of the subway to ten years, and provides that any such contract may be terminated at any time by this Commission on giving sixty days' notice in writing.

Under the act, as it was passed two years ago, authorizing this Commission to make a contract for the use of the subway for a term not exceeding fifty years, we are confident that a contract could be made on

such terms that the tax levy of the city of Boston would not be increased in consequence of the outlay for the construction of the subway; or, in other words, that an annual payment for the use of the subway could be secured which would be sufficient to pay the interest on the debt incurred, and also such further sum as might be necessary to create a sinking fund sufficient to pay the debt at its maturity. Thus, at the end of forty years, the term for which the bonds run as fixed by said law, the city would be the owner of the subway, fully paid for by its income, without any tax levy. It is clear that a corporation negotiating for the use of the subway would not be willing to pay so large an annual rental for a short-term contract as for a long-term contract; and yet a short-term contract would naturally result in a larger expenditure by the city from time to time for repairs, alterations, and for equipment with electrical plant, etc. Especially would this be the case at the end of each term, when negotiations for a new term are in progress.

It may be true that the value of the subway will in the future prove to be greater than at present anticipated, but it must be borne in mind, on the other hand, that if the policy of short terms is adopted it will be for the interest of the corporations using the subway to depreciate its value, and from time to time to ask for large expenditures for repairs and alterations. The short term is, therefore, more speculative and the long term more conservative.

The provision that the Commission can terminate the contract at any time upon sixty days' notice would further diminish the amount which any street-railway company will be willing to pay. No advantage would accrue to the public at all commensurate with the certain loss. Street-railway companies can only get access to the subway over the streets of the city of Boston, and of the adjoining cities and towns. If a street-railway company which has contracted for the use of the subway fails to serve the public properly, a revocation of its right to pass over such streets would place it in a position in which it would be under contract to pay a large annual rental for a piece of property which it could not utilize to advantage. The control of the municipal corporations over it would be no less than at present. Such control might be greater than at present.

Passing now to the consideration of the second bill, which forbids the making of any contract for the exclusive use of the subway, this bill also will further diminish the amount which a street-railway company may be willing to pay.

Other disadvantages would result: With several competing corporations independently using the subway under separate leases there would be a clashing of interests, from which the public is likely to suffer. The chance of accident would be greater and the responsibility for accident less easily determined.

Results which will better promote the interests of the public and at the same time be more conservative, and which will ensure more efficient service by the street-railway companies, can be secured under the law as it now stands.

This letter has been read to the members of the Commission, and the statements herein made meet with their unanimous approval, and they desire me to state that it is their deliberate judgment that if the present law is amended as proposed the city of Boston cannot obtain from the subway either the service or the financial returns which can be secured under existing conditions.

You are at liberty to make such use of this letter as you desire. It is only fair that the Senate should be informed of the views of the Commission.

Yours very truly,

(Signed) GEORGE G. CROCKER,
Chairman.

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TREMONT ST.
PEMBERTON SQ.
UP
PLATFORM
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ROW
ATTLE ST.
ST.
HANOVER ST.

Change of Route.

In the first annual report, in describing the route of the subway as provisionally adopted, it was stated that it was proposed to run two tracks in Cornhill and the other two tracks in Brattle street, and the design for the station at Scollay square was shown, having an interior loop similar to that at Park street for the use of cars coming from the north and going no further south than Scollay square. The stopping-place for the cars was on the loop itself, and the radius of the loop, being determined by the position of Cornhill and Brattle street, was only about fifty feet.

An alternative route was to use Hanover street instead of Brattle street for the two south-bound tracks.

The Hanover-street route has been adopted. It more nearly conforms to the present routes of the cars. It renders possible more ample station-accommodations and better facilities for handling a large traffic. The stopping-place for the cars, both for those which go through to the south and those which reverse, is practically a straight piece of track, and is of sufficient length. (See Plates A and B.)

As incidental to the adoption of the Hanover-street plan, it has been decided to construct in Adams square an additional loop.

The present plan, together with some of the other plans which have been considered, are shown in a cut in the report of the Chief Engineer.

Southern Tremont-street Entrance.

The location of the southern Tremont-street entrance having been fixed in the triangle bounded by Tremont street, Shawmut avenue, and Pleasant street, it has been further decided to construct a sub-subway near that point, so as to avoid a crossing at grade similar to that which now occurs on the surface at the junction of Shawmut avenue and Tremont street, where the inbound Tremont-street track crosses the outbound Shawmut-avenue track. In the report of the Chief Engineer will be found a sketch showing the method by which the crossing at grade is avoided.

Plans for the construction of the incline contemplate the erection over the subway of some suitable building. The Commission does not propose to erect the building, but to sell or lease the premises, subject to the subway easement, fixing the conditions under which the purchaser or lessee may build.

Within the triangle there will be a stopping-place for the cars, with suitable platforms and convenient entrances.

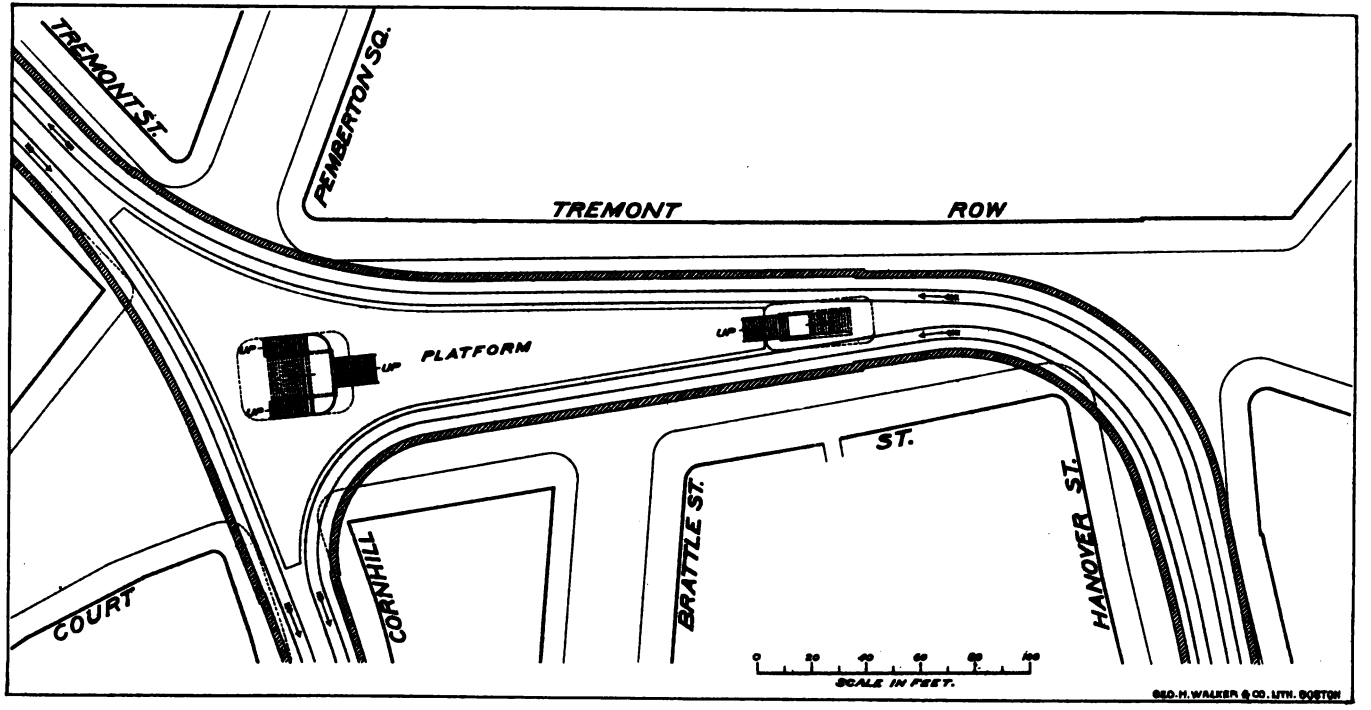

PLATE A. PLAN OF SCOLLAY SQUARE STATION.

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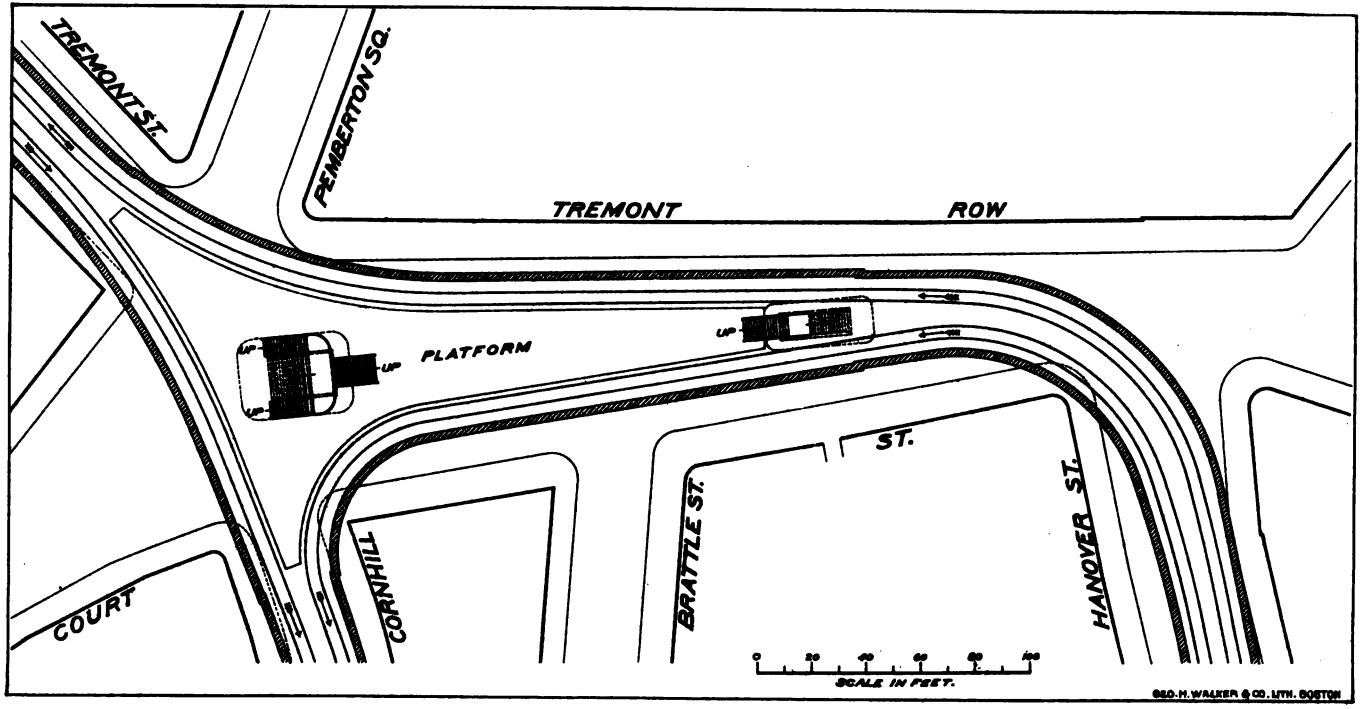

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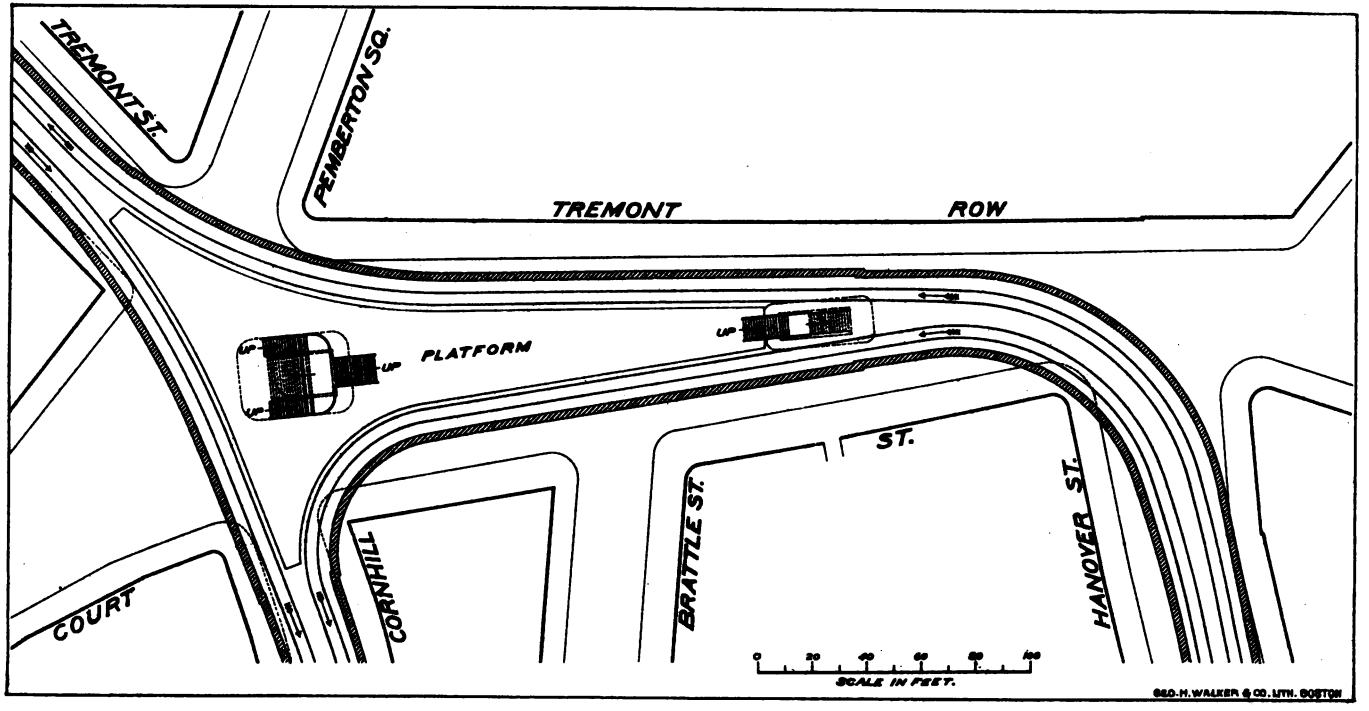

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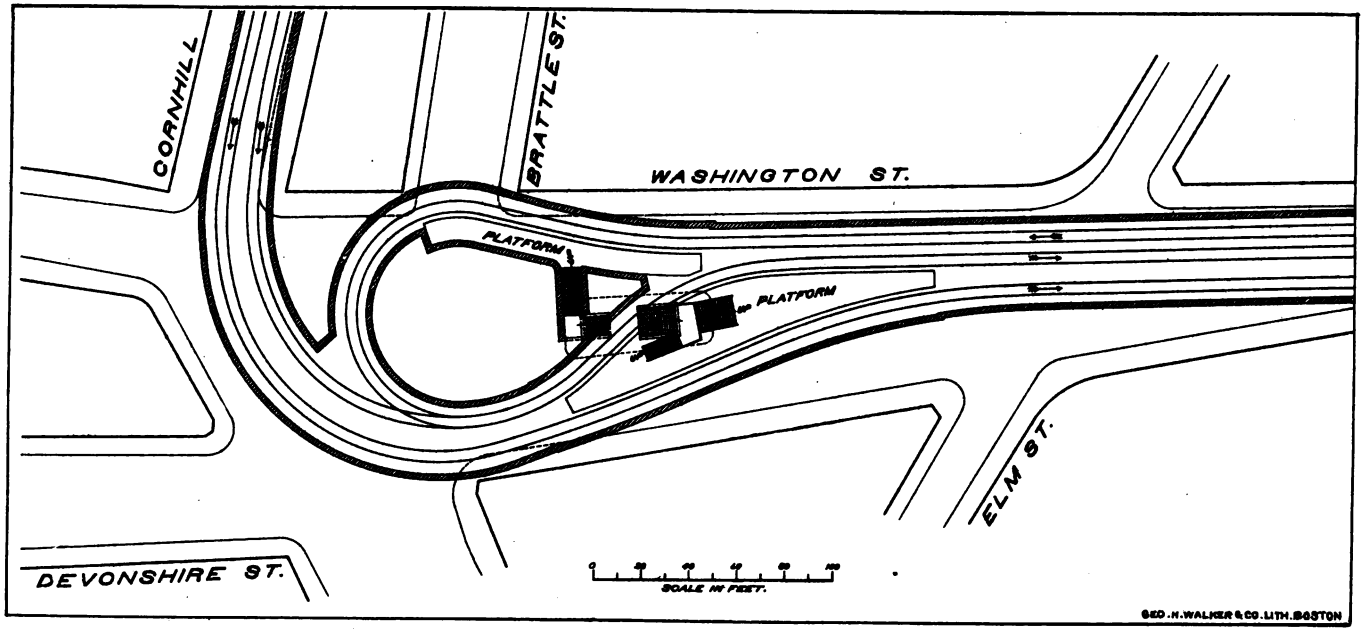


PLATE **B.** PLAN OF ADAMS SQUARE STATION.

PLATE C. — SOME GRAVESTONES FOUND NEAR PARK STREET.

PLATE D.— SOME GRAVESTONES FOUND NEAR PARK STREET.

PLATE E. — SOME GRAVESTONES FOUND NEAR PARK STREET.

The Common and the Public Garden.

In the last annual report reference was made to the reasons for regrading portions of the Common and the Public Garden, and the methods to be adopted. During the past year the work on the Public Garden has been completed, and that on the Common, which was more extensive, has so far progressed that it will be finished in the early spring of 1897. By using in these regradings the earth excavated from the Tremont and Boylston street malls the work of building the subway has progressed more easily and rapidly, and the dump-cart has, to that extent, been kept off the streets.

The Commissioners see no reason to alter the opinion previously expressed, that the changes will not diminish, but will increase, the beauty both of the Common and the Garden.

The results of raising some fifty trees to the higher level cannot be fully known for at least another year. Six have died. No attempt was made to raise trees exceeding twenty inches in diameter. There is reason to expect that those which have survived will be benefited by the change, as they will have better drainage and in some cases richer soil.

During the progress of excavation twelve tombstones and one human skeleton were unearthed about 70 to 80 feet west of Tremont street, between the northerly line of Winter street and Park street. The stones were lying in a horizontal position, about four feet below the surface (none being near the skeleton), and bear the following names and dates:

Edward Porter	July 29, 1677.
An. Gellum	November 11, 1678.
Seth Baker	July 13, 1697.
Joseph Simpson	March 12, 1708 or 1709.
William Cole	April 13, 1710.
Edward Mortimer	December 9, 1678.
Precilla Mann	September 21, 1716.
John Indicott	August 22, 1686.
John Wakefield	August 11, 1715.
Rebecca Cossen	November 24, 1721.
Children of Rowley	1680.
John Smith.	

It having been necessary to disturb these memorials, it is deemed proper to place photographs of them in the pamphlet containing this report. (See Plates C, D, and E.) The stones will be carefully preserved.

Elevators.

In the City and South London (subway) Railway, and other similar railways now under construction in London by the Greathead system, large vertical elevators are pro-

vided for carrying passengers to and from the platforms. This provision is necessary in consequence of the great depth of the railway below the surface.

Such an arrangement would not be desirable where the height to be traversed is so small as in the Boston subway. The Commission, however, has it in mind to study this matter in order to inform itself whether a moving incline can be used whereby passengers can be carried from the platforms to the surface, with rapidity and safety, in case any persons desire to be so carried instead of walking up the stairway.

Mail Service.

The question having arisen as to whether some arrangement, other than the ordinary stairway, should not be made in the subway, for transferring mail-bags to and from post-office cars, inquiry was made on the 9th of January of Hon. J. W. Coveney, Postmaster of the City of Boston, and the following is a copy of his reply:

OFFICE OF THE POSTMASTER,
BOSTON, MASS., January 20, 1896.

H. A. CARSON, Esq., *Chief Engineer, 20 Beacon Street, Boston:*

MY DEAR SIR: Referring to yours of the 9th inst., relative to mail-bags to and from postal cars in subway, will say that I have looked into this matter thoroughly, and can find no necessity for any special arrangements for getting mail-bags to and from postal cars, as, so far as I can see, at all points where mail is received and delivered the cars will be run on the surface. There are but two routes in the electric postal service that can possibly be affected; namely, the Dorchester and Back Bay, and Boston and Somerville railway post-offices. The former can leave Lenox-street stable, running via Tremont street and subway and come to the surface on Haverhill street, receiving mail on the surface in front of Union Station. This railway post-office makes but one trip to the Union Station and *receives* mail only. The Boston & Somerville railway post-office will run on the surface at all times, and receive and deliver mail at the corner of Nashua and Causeway streets, as at present.

Should a pneumatic-tube service be adopted, as it should be, for a better service to business men and others within this postal district, I may be compelled to advise you in relation to the same, when I shall be glad to do so, and give you the full details of the scheme, as far as it bears upon the question of subway transit.

Very truly yours,

(Signed) JOHN W. COVENEY,
Postmaster.

Mr. C. S. Sergeant, General Manager of the West End Street Railway Company, also wrote, that after careful consideration he could see no reason whatever for such provision, "understanding that there will be a ready ingress and egress from and to the surface for the cars at Causeway street."

Sewer and Drain Pipes.

On May 11, 1896, upon report of the Chief Engineer, it was voted to be inexpedient to place sewer or drain pipes within the walls of the subway.

Negotiations for the Use of the Subway.

Under date of June 19, 1896, the Commission, by public advertisement, gave notice to parties desiring to negotiate for the use of the subway that applications would be received up to and including July 20, 1896. In response to this advertisement a letter was received from Mr. Samuel Little, President of the West End Street Railway Company, stating that at a meeting of the Board of Directors held June 16, 1896, it was voted that the Executive Committee be authorized to at once take up the matter of leasing the subway with the Boston Transit Commission, and ascertain the terms on which such lease may be obtained, and a request for an interview upon the subject was made.

A communication was also received, signed by George A. Lancaster, of Revere, and James H. Mellen, of Worcester, of which the following is a copy:

APPLICATION FOR USE OF THE SUBWAY BY GEORGE A. LANCASTER AND OTHERS, ASSOCIATED FOR THE FORMATION OF THE LANCASTER ELEVATED RAILWAY COMPANY.

George A. Lancaster, of Revere, Mass., James H. Mellen, of Worcester, Mass., and their associates of Boston, Brookline, New York, Philadelphia, and elsewhere, hereinafter called the "associates," makes the following application for the use of the subway in Boston under the authority of the Acts of the Legislature of 1894, chapter 548; 1895, chapter 440; and 1896, chapter 492. The corporation being formed by the associates and for the charter of which they have already filed a petition with the Secretary of this Commonwealth, as provided by law, is an elevated and street railway company to construct, maintain, and operate an elevated and street railway in the city of Boston, according to the plans and patents of George A. Lancaster or such other plans and patents as they may select. The company will have a paid-up capital of not less than one million dollars, and this application, if accepted, will be undertaken by the company in good faith and thoroughly performed by it.

The elevated railway company will, in the course of its operation, make leases and traffic arrangements with street railway lines, operating cars in and about the city of Boston, and will use the subway in connection with its elevated and street railway and the leased or connecting lines of street railways which may from time to time join with the elevated railway company in operating their line.

The elevated railway company will agree to pay to the Subway Commissioners for the right to operate cars through the subway and its branches the sum of twelve dollars and fifty cents ($12.50) per hundred cars run through the subway by the elevated railway company, or by any companies leased by it, or operating under traffic arrangements with it. The elevated railway company will keep an account of the number of

cars run through the subway by it or its leased or allied companies, and will settle the account with the Board of Subway Commissioners within thirty days from the first day of January and July in each year. The time for which this application is made is twenty years.

The elevated railway company in operating its cars will furnish such free transfers from one part of the city to others, over its lines or the lines of its allied companies, as may be commercially practicable under the conditions of operating the cars through the subway, and will furnish a satisfactory bond with good sureties for the performance of this offer on its part, if it is accepted.

This offer is made by the associates on the understanding that the tracks through the subway are to be constructed by some other street railway company, or by the Subway Commissioners themselves, under the authority of the subway acts, and that the electric or other motive power is likewise to be furnished by some other parties. If the Commissioners prefer to have a bid for the construction of tracks and furnishing of power equipment by the elevated railway company, said company desires to have a further opportunity to submit a bid based on estimate of the cost of construction and equipment.

The associates desire also to make application for the use of the subway for various commercial purposes to which it might be conveniently applied, such as pneumatic tubing for the transportrtion of merchandise, conduits for the carrying of electric wires, and the like, but understand that these purposes are not authorized by the existing laws relating to the subway, and would desire the Commissioners to consider whether it would not be advisable to defer final action upon the question of the occupation of the subway until an opportunity has been given for the amendment of the subway acts so as to allow its use for the various important commercial purposes which the convenience and comfort of the citizens of Boston require.

(Signed) G. A. LANCASTER,
JAMES H. MELLEN.

A letter was also received from Messrs. Proctor & Warren, counsel, Lynn & Boston Railroad Company, under date of July 20, 1896, stating that "The Lynn & Boston Railroad Company desires to be considered as an applicant for the use, in part, of the subway now in process of construction."

These three applications were the only ones received. Between the twentieth of July and the date of this report several conferences were held with the applicants, either by the Commission or by a committee. No other action was taken.

Residence of Employees.

On June 8, 1896, a request was received from the Board of Aldermen, transmitted by His Honor the Mayor, for a list of all persons and contractors employed on the subway not residents of Boston. The following is a copy of the reply:

JUNE 15, 1896.

To His Honor the Mayor:

DEAR SIR: The Boston Transit Commission furnishes the following, in compliance with the request of the Board of Aldermen, this day received, for a list of all persons and contractors employed by this Commission on the subway who are not residents of Boston:

In Engineering Department.

George M. Bacon,
Howard A. Carson,
Walter F. Clare,
J. Albert Cole,
Samuel Corning,
James E. Coyne,
Russell L. Elliott,
George P. Goodman,
Sumner Gowan,
Peter Hermanson,
Horace J. Howe,
William W. Lewis,
John E. Newlands,
Patrick F. O'Brien,
A. W. Parker,
Chauncey R. Perry,
George H. Stearns,
Frank L. Tibbetts,
Francis H. Watts,
Charles A. Wentworth,
J. R. Worcester.

Contractors.

E. W. Everson, Charles Linehan,
F. E. Shaw.

The total number of persons on the pay-rolls of the Commission is one hundred and ninety-three.

Yours respectfully,

(Signed) GEORGE G. CROCKER,
Chairman.

Inspections.

Upon the practical completion of Section One of the subway, His Honor Roger Wolcott, Acting Governor of the Commonwealth; the members of the Executive Council; the heads of the State departments; the members of the Senate and House of Representatives; His Honor the Mayor of the city and the heads of the city departments, and the members of the Board of Aldermen and of the Common Council, were invited to inspect the subway work. The invitation was accepted by His Honor Acting Governor Wolcott, His Honor the Mayor, and one hundred or more members of the State and city governments.

CHARLESTOWN BRIDGE.

On September 3, 1895, the City Engineer presented plans and general specifications for the Charlestown bridge, suitable to accompany a petition to the Harbor and Land Commission for its approval. On September 4 the petition to said Commission was duly presented. On September 17 a public hearing was given by that Commission. On October 30, in accordance with an informal suggestion received from the Harbor and Land Commission, an amended plan was submitted in which the clear opening at the draws was definitely fixed at twenty-three feet, instead of being left with some latitude, as in the original plans. On November 29 the following license of the Harbor and Land Commission was issued:

COMMONWEALTH OF MASSACHUSETTS.

No. 1859.

Whereas, the Boston Transit Commission, of Boston, in the county of Suffolk and Commonwealth aforesaid, has been authorized and required by the General Court, by chapter 548 of the Acts of the year 1894, to construct a bridge over Charles river, between the present Charles-river bridge and the Fitchburg-railroad bridge, in the city of Boston in the county of Suffolk and Commonwealth aforesaid; and, before beginning said work, has given written notice to the Board of Harbor and Land Commissioners of the work intended to be done, and submitted, for the approval of said Board, general plans of said bridge; and whereas due notice of said application, and of the time and place fixed for a hearing thereon, has been given, as required by law, to the Mayor and Aldermen of the city of Boston:

Now, said Board, having heard all parties desiring to be heard, and having fully considered said application, hereby approves the plans for said work hereto annexed; and, subject to the approval of the Governor and Council, hereby authorizes and licenses said work to be done in accordance therewith, subject to the provisions of the nineteenth chapter of the Public Statutes, and of all laws which are or may be in force applicable thereto.

The work hereby licensed and approved is the construction of an iron bridge on stone piers, across Charles river, between the present Charles-river bridge and the Fitchburg-railroad bridge in the city of Boston, said bridge to be about one thousand and seventy feet in length between abutments and one hundred feet wide; said piers to be not less than eighty feet apart on centres. There shall be two draw openings in said bridge for the passage of vessels, each fifty feet wide; and the clear head-room under the draw spans shall be not less than twenty-three feet above mean high water.

Detailed plans and specifications, showing the location and dimensions of said work and the mode in which the same is to be performed, shall be submitted to said Board for approval.

A duplicate of the aforesaid plan, numbered 1859, remains on file in the office of said Board, and said work is to be executed under its supervision.

Nothing herein contained shall be so construed as to impair the legal rights of any person.

This license shall be void unless the same, and the accompanying plan, are recorded, within one year from the date hereof, in the Registry of Deeds for the County of Suffolk.

In witness whereof, the said Harbor and Land Commissioners have hereto set their hands this twenty-fifth day of November, in the year eighteen hundred and ninety-five.

(Signed) WOODWARD EMERY,
JOHN I. BAKER,
CHAS. H. HOWLAND,
Harbor and Land Commissioners.

COMMONWEALTH OF MASSACHUSETTS.

BOSTON, November 27, 1895.

Approved by the Governor and Council.

(Signed) E. F. HAMLIN,
Executive Clerk.

[Recorded in Suffolk Registry of Deeds, September 16, 1896, — lib. 2386, fol. 625.]

Upon the receipt of the foregoing license, application was forthwith made to the United States government for its approval, and on December 30, 1895, its license was issued, as follows:

Whereas, by section 3 of an act of Congress, approved July 13, 1892, entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," it is declared that it shall not be lawful to construct by authority of the legislative act of a State any bridge not already authorized by law over a navigable water of the United States, wholly within the limits of such State, without the approval by the Secretary of War of the location and plans of such bridge; and whereas the Boston Transit Commission, having authority under an act of the legislature of the State of Massachusetts to construct a bridge over Charles river at Boston, in said State, has submitted a map of the location and plan of the same;

Now, therefore, this is to certify that the map of location and plans of said bridge, which are hereto attached, are hereby approved by the Secretary of War, subject to the following conditions:

1. That the engineer officer of the United States army, in charge of the district within which the bridge is to be built, may supervise its construction, in order that said plans shall be complied with.

2. That the old "Charles-river bridge" be entirely removed between the harbor lines, and that a suitable draw rest and guard be provided on the lower side of the bridge to facilitate passage of vessels through the draw.

WITNESS my hand this twenty-seventh day of December, 1895.

(Seal) (Signed) DANIEL S. LAMONT,
Secretary of War.

Upon the receipt of the foregoing license, the City Engineer was instructed to proceed with the construction plans of the bridge.

On June 24, 1896, the necessary preliminary borings having been made and the nature of the foundations having been determined, construction plans for the piers were presented and approved by this Commission, and an advertisement was issued for bids for their construction. The contract therefor was awarded on July 20, and work upon it has begun this day.

On July 30, wharf property on both sides of the river was taken by right of eminent domain. [Recorded in Suffolk Registry of Deeds, July 30, 1896, — lib. 2378, fol. 213.]

It is expected that it will take until the autumn of 1897 to finish the construction of the piers of the bridge so that they will be ready for the superstructure.

Plans and statistics in relation to the bridge will be found in the report of William Jackson, Chief Engineer.

EAST BOSTON TUNNEL.

On September 19, 1895, the following report of the Chief Engineer was transmitted to the Common Council of the

city of Boston, in accordance with its request for information:

SEPTEMBER 12, 1895.

To the Boston Transit Commission:

GENTLEMEN: In accordance with your request, I submit herewith an estimate of cost for a tunnel from Boston proper to East Boston. Various routes have been considered, as well as various sizes and cross-sections for the tunnel, and also various methods of construction. The estimate given herewith contemplates an open incline from a point on Hanover street, descending at the rate of 5 feet in 100. From the end of the open incline, a single-tube subway suitable for a double track is to be built by open-trench excavation, then a double-tube structure, each tube being 12 feet wide and 16 feet high, inside measurement, passing under the harbor. The portion under the harbor would be nearly level. This portion could be built by dredging and putting in the tubes in sections about 50 feet in length, in a manner similar to that used in building the Metropolitan main sewer under Shirley gut and from the southerly end of Deer island. The top (outside) of each tube between the harbor lines would be nowhere less than 35 feet below low water. On the East Boston side the tunnel would come again to the surface at Maverick square, with an ascending grade of about 5 feet in 100, and sizes and methods of construction similar to that on the Boston side.

The total length of the structure, including inclines, would be about 4,775 feet.

Each of the tubes mentioned would be wide enough to accommodate a single line of surface cars of the ordinary size, and admit of a narrow walk on each side, which would allow passengers to walk in case the cars should be stopped for any reason.

Estimated cost, including administration, engineering, and contingencies	$2,052,600
Land damages	354,000
Total	$2,406,600

Respectfully submitted,

(Signed) H. A. CARSON,
Chief Engineer.

On November 11, 1895, the following order from the City Council was received:

"*Ordered*, That the Boston Transit Commission be hereby requested to proceed, at its earliest convenience, with the work of constructing a tunnel between East Boston and the City proper, as authorized by section 28, chapter 548, of the Acts of 1894."

The expenditure which this Commission is authorized to make for the construction of subways is limited to $7,000,000. Based upon the estimates, this appropriation would be insufficient to build both the subway now in process of construction and the tunnel to East Boston. The Commission is, therefore, of the opinion that it is not justified at the present time in taking further steps towards the construction of the tunnel.

ISSUE OF BONDS.

Under the Acts of 1894, chapter 548, section 37, bonds to the amount of $750,000 have been issued during the year on account of the subway. The rate of interest on these bonds is three and one-half per cent., and the total premium received amounted to $10,862.50, which has been paid into the sinking fund.

In December, 1895, bonds to the amount of $10,000, upon which the rate was four per cent., were issued in accordance with the request of the Commission to meet expenses incurred or to be incurred on account of the proposed bridge to Charlestown. These bonds were taken by the Sinking Fund Commissioners at par.

PAYMENTS TO SINKING FUND.

The following premiums on bond issues and receipts from all sources have been paid into the Rapid Transit Sinking Fund:

1895.		
April.	Premium on $1,000,000 4 % bonds	$139,100 00
Dec. 12.	Adjustment of loss by fire, Canal-street sheds .	544 00
1896.		
Jan.	Premium on $250,000 3½ % bonds	1,562 50
Jan. 9.	Adjustment of loss by fire, Canal-street sheds .	930 00
April.	Premium on $500,000 3½ % bonds	9,300 00
April 1.	Sale of old buildings, Shawmut-avenue triangle,	450 00
April 22.	Rentals, Haymarket-square property	8,017 17
April 22.	" Shawmut-avenue triangle	4,534 26
April 27.	Rebate on insurance policies, Shawmut-avenue triangle	26 10
		$164,464 03

GENERAL STATEMENT.

Some of the more important features of the work of the Commission have been set forth. Work on details has consumed a far greater amount of time, but this report should not be cumbered with a statement of them. They may be classified under the following headings:

The Terms of Contracts.

Conferences with Contractors.

Claims of Contractors.

Pushing Contractors to fulfil their agreements in quality of work and in time.

Station Plans, especially plans for the Northern Terminal.

Suggested Changes of Route.

Methods of Utilizing the Real Estate bounded by Tremont street, Shawmut avenue, and Pleasant street, and the Hay-

market square property, subject to the easement of the subway.

Materials and Quality of Finish of the Subway along the route and at the stations.

Hearings and determination as to the value of real estate taken, and awards therefor.

The Rights of Individuals owning or occupying real estate on the route of the subway, and their claims for damages.

The Rights of Gas Companies, Electric Light Companies, and Telephone Companies, and their claims for reimbursement of the cost of changing locations of their pipes and conduits.

Claims for Damages for personal injuries by employees and other citizens.

Means of reducing to the lowest possible terms the inconveniences and dangers to abutting owners or occupants and to the public resulting from construction-work.

Consultations with the Street, Water, and Electric Wire Departments of the city and with the Police.

The Terms and Conditions which should be embodied in any contract for the use of the subway.

Examination of Expenditures; and a large amount of incidental matters which cannot be readily classified.

Owing to the fact that the construction is not of an ordinary character, questions not infrequently have arisen in regard to which there are no precedents to guide either the Commission, the contractors, or the public.

STATEMENT OF EXPENSES.

The following is a classified statement of the expenses of the Commission, for the year ending August 15, 1896:

SUBWAY.

General Expenses:		
Office — Repairs	$454 19	
Furniture	263 56	
Supplies	936 59	
Stationery and printing	1,471 41	
Fuel and light	169 14	
Rental	1,375 00	
Stenographers	1,395 00	
Messenger	756 75	
Janitor	209 30	
Salaries of Commissioners and Secretary	28,000 33	
Total	$35,031 27	
General Expenses: 4–5 to Subway		$28,025 02
Carried forward,		$28,025 02

Brought forward,		$28,025 02

ENGINEERING DEPARTMENT.

Rooms — Repairs	$1,035 66	
Furniture	703 25	
Supplies	2,538 12	
Stationery and printing	1,688 23	
Fuel and light and heat	207 56	
Rental	1,500 00	
Janitor	289 80	
Messengers	366 67	
Stenographer	2,112 92	
Instruments	1,494 59	
Supplies	12,038 50	
H. A. Carson, Chief Engineer	8,000 00	
Skilled service	49,686 34	
Total		81,661 64

MISCELLANEOUS.

Legal and expert advice	$2,220 45	
Advertising	518 74	
Labor	10,817 59	
Counting travel	65 00	
Pipe sewer, Common	1,470 15	
Stripping Common	3,849 50	
Total		18,941 43

SECTION ONE.

(*Public Garden to old Public Library, 2-track; Tremont street from north of Mason to West street, 4-track; completed.*)

Jones & Meehan	$93,213 60	
Pennsylvania Steel Co.	19,420 04	
Department of Public Grounds	13 90	
Legal and expert advice	784 19	
G. W. G. Ferris & Co.	491 48	
Construction	8,695 63	
Teaming	574 63	
Office supplies	80 60	
Field supplies	1,568 08	
Stationery and printing	1 50	
Fuel and light	11 50	
Rental	183 34	
Care of human remains	345 00	
Relocating pipes	1,157 17	
Labor	3,629 60	
Total		130,170 26

SECTION TWO.

(*Old Public Library to north of Mason street, 2 and 4 track, and station; under contract.*)

E. W. Everson	$47,061 46	
Pennsylvania Steel Co.	71,254 67	
Carried forward,	$118,316 13	$258,798 35

Brought forward,	$118,316 13	$258,798 35
G. W. G. Ferris & Co.	696 44	
Construction	16,490 59	
Legal and expert advice	5 00	
Office supplies	232 25	
Field supplies	2,021 02	
Advertising	136 51	
Stationery and printing	186 35	
Labor	5,095 05	
Relocating pipes, etc.	1,107 80	
Total		144,287 14

SECTION THREE.

(*West street to Park street, 4-track and station; under contract.*)

F. E. Shaw	$32,512 44	
Pennsylvania Steel Co.	53,695 35	
G. W. G. Ferris & Co.	656 96	
Construction	2,412 82	
Office supplies	224 15	
Field supplies	550 84	
Advertising	110 15	
Stationery and printing	118 17	
Labor	2,769 56	
Teaming	388 47	
Rental	199 99	
Relocating pipes	3,542 16	
Total		97,181 06

SECTION THREE AND ONE-HALF.

(*About 25 feet each of two single-track subways from Section 3 to Section 6; completed.*)

E. W. Everson	$7,722 27	
Office supplies	20	
Field supplies	140 19	
Construction	1,001 60	
Stationery and printing	7 50	
Labor	324 36	
Relocating pipes	115 00	
Total		9,311 12

SECTION FOUR.

(*Tremont street, Section 2, to Hollis street, 2-track; Hollis to Warrenton street, 4-track; under contract.*)

New Jersey Steel & Iron Co.	$24,050 30	
Metropolitan Construction Co.	93,977 33	
G. W. G. Ferris & Co.	274 90	
Construction	14,961 88	
Legal and expert advice	350 00	
Rental	150 00	
Fuel and light	15 15	
Office supplies	135 66	
Field supplies	3,368 11	
Carried forward,	$137,283 33	$509,577 67

Brought forward,	$137,283 33	$509,577 67
Stationery and printing	186 90	
Labor	18,093 52	
Teaming	3,166 71	
Relocating pipes	3,223 13	
Advertising	225 15	
Eliot-street sewer	6,463 62	
Underpinning	14,933 71	
Total		183,576 07

SECTION FIVE.

(*Warrenton street to Pleasant street, 4-track and station.*)

Advertising	$55 75	
Legal and expert advice	1,250 00	
Field supplies	62 95	
Stationery and printing	3 00	
Teaming	16 20	
Labor	70 69	
Total		1,458 59

SECTION SIX.

(*Tremont street, Section 3½, to near Scollay square, 2-track; under contract.*)

R. A. Malone & Co.	$15,799 63	
Construction	886 37	
Advertising	251 93	
Office supplies	100 88	
Field supplies	503 22	
Stationery and printing	112 95	
Teaming	526 50	
Labor	2,906 60	
Total		21,088 08

SECTION SEVEN.

(*Scollay-square Station.*)

Field supplies	$8 50	
Teaming	28 15	
Labor	43 38	
Total		80 03

SECTION EIGHT.

(*Hanover street, Section 7 to Section 9, 2-track.*)

Construction	$36 00	
Field supplies	48 36	
Teaming	235 75	
Labor	1,940 95	
Relocating pipes	412 82	
Total		2,673 88
Carried forward,		$718,454 32

Brought forward,		$718,454 32

SECTION EIGHT AND ONE-HALF.

(*Cornhill, Section 7 to Section 9, 2-track.*)

(No expenditures to date.)

SECTION NINE.

(*Adams square, Washington street to Hanover street, 2-track and station.*)

Construction	$60 17	
Field supplies	8 50	
Teaming	28 15	
Labor	457 84	
Total		554 66

SECTION TEN.

(*Washington street, from Hanover street to Haymarket square, 4-track and station at Haymarket square; partly under construction by Commission.*)

Construction	$60 17	
Office supplies	4 69	
Field supplies	125 55	
Teaming	73 80	
Labor	2,781 40	
Total		3,045 61

SECTION ELEVEN.

(*Haymarket square to Causeway street, 4-track and 2-track and incline.*)

Legal and expert advice	$225 00	
Labor	1,113 23	
Miscellaneous	122 26	
Total		1,460 49

EAST BOSTON TUNNEL.

Field supplies	$165 45	
Labor	557 98	
Skilled service	177 30	
Teaming	35 40	
Total		936 13

INTEREST.

Paid by City Treasurer		47,029 38

CHARLESTOWN BRIDGE.

General expenses: 1–5 to bridge	$7,006 25	
Stationery and printing	100 50	
Office supplies	74 06	
Field supplies	430 24	
Advertising	175 05	
Labor	1,862 76	
Legal and expert advice	50 00	
Counting travel	2 19	
Carried forward,	$9,701 05	$771,480 59

Brought forward,	$9,701 05	$771,480 59
Teaming	22 20	
William Jackson, Chief Engineer	2,500 00	
Skilled service	2,813 09	
Total		15,036 34
		$786,516 93

SUMMARY.

	To Aug. 15, 1895.	Aug. 15, 1895, to Aug. 15, 1896.	Total.
Subway.—Subway Commission	$14,131 16		$14,131 16
4–5 General Expenses	27,108 03	$28,025 02	55,133 05
Engineering Expenses	33,210 97	81,661 64	114,872 61
Miscellaneous	13,983 50	18,941 43	32,924 93
Section One	67,157 32	130,170 26	197,327 58
Two	716 97	144,287 14	145,004 11
Three		97,181 06	97,181 06
Three and one-half		9,311 12	9,311 12
Four	1,343 53	183,576 07	184,919 60
Five		1,458 59	1,458 59
Six		21,088 08	21,088 08
Seven		80 03	80 03
Eight		2,673 88	2,673 88
Nine		554 66	554 66
Ten		3,045 61	3,045 61
Eleven	751,154 51	1,460 49	752,615 00
East Boston Tunnel	193 31	936 13	1,129 44
Interest		47,029 38	47,029 38
Total	$908,999 30	$771,480 59	$1,680,479 89
Bridge. — 1–5 General Expenses	$6,777 01	$7,006 25	$13,783 26
Engineering Expenses	1,479 09	8,030 09	9,509 18
Total	$8,256 10	$15,036 34	$23,292 44
Grand total	$917,255 40	$786,516 93	$1,703,772 33

The reports of the Chief Engineer and of the Chief Engineer for Charlestown Bridge are appended.

GEORGE G. CROCKER,
CHARLES H. DALTON,
THOMAS J. GARGAN,
GEORGE F. SWAIN,
ALBERT C. BURRAGE,
Boston Transit Commission.

REPORT OF THE CHIEF ENGINEER.

BOSTON, August 15, 1896.

GEORGE G. CROCKER, CHARLES H. DALTON, THOMAS J. GARGAN, GEORGE F. SWAIN, ALBERT C. BURRAGE, *Boston Transit Commissioners:*

GENTLEMEN: I submit herewith a detailed report of the work done during the past year on various sections of the subway, together with some general remarks in regard to progress, methods employed, cost, and other topics.

The names of some of the assistants in the Engineering Department are given below, together with an indication of the work on which they have been engaged.

OFFICE ASSISTANTS, AUGUST 15, 1896.

Assistant Engineers.

EDMUND S. DAVIS. General oversight of field, and miscellaneous office work.
CHARLES H. SWAN. Studies for changes in sewers, pipes, etc.
JOSEPH R. WORCESTER. Designs for steel work.
HORACE J. HOWE. Preliminary surveys and studies for stations.
WILLIAM W. LEWIS. Studies for locations and designs for subways.
A. N. WAHLBERG. Studies for locations and designs for subways.

Draughtsmen, Transitmen, etc.

JOHN WORCESTER, Draughtsman.
J. ALBERT COLE, Draughtsman.
CHAUNCY R. PERRY, Draughtsman.
GEORGE H. STEARNS, Draughtsman.
JOSEPH A. ROURKE, Draughtsman.
SHERMAN A. JUBB, Draughtsman.
WILLIAM F. MANN, Draughtsman.
A. F. BILDT, Draughtsman.
HENRY R. KIMBALL, Draughtsman.
G. HERBERT BRAZER, Draughtsman.
RUSSELL L. ELLIOT, Draughtsman.
J. W. CLARY, Draughtsman.
SUMNER GOWEN, Draughtsman.
J. W. KILLAM, Draughtsman.
WILLIAM J. J. YOUNG, Draughtsman.
LEONARD H. DAVIS, Assistant on Pipe Changes.
L. B. MANLEY, Assistant on Pipe Changes.
E. ST. J. MAUNSELL, Transitman.
NELSON A. HALLETT, Cement Tester.
ARTHUR B. CARTER, Clerk and Stenographer. Correspondence, collected and compiled data.
JOHN A. SULLIVAN, Stenographer.
JAMES P. LYNCH, Stenographer.
WALTER F. CLARE, Assistant for Purchasing Supplies.

CHARLES F. CAHILL, Assistant.
FRED W. STILES, Plan-keeper.
W. N. KENYON, Blue-printer.
GEORGE P. GOODMAN, Photographer.
F. L. TIBBETTS, Rodman.

FIELD ASSISTANTS, AUGUST 15, 1896.

GUY C. EMERSON, Assistant Engineer. General inspection.
A. W. PARKER, General steel inspection.
JOHN E. NEWLANDS, Assistant on steel inspection.
J. T. R MCMANUS, Assistant on steel inspection.
E. A. CLARK, Foreman for Borings.

The names of the other and much the larger portion of the field assistants are given in the accounts of the sections on which they have worked.

PROGRESS.

Excavation on the subway began March 28, 1895, or about sixteen months ago. The portions of the subway that have been completed at this date (August 15, 1896), those that are now under construction, those that are projected, together with other information, can be seen on the progress map which immediately precedes this report. A detailed statement of progress can be found in the reports of the particular sections beginning on page 36.

The following general statement may be given here:

Section 1. Is completed.
" 2. About 70 per cent. of the excavation is completed.
" 3. About 69 per cent. of the excavation is completed.
" 3½. Is completed.
" 4. About 51 per cent. of the excavation is completed.
" 5. Buildings have been removed.
" 6. About $\frac{1}{5}$ of the excavation is completed.
" 10. Excavation near buildings has been begun. Steel work for side-walls is under way.

The percentage of masonry and steel construction is somewhat less than the percentage of excavation on all but the completed sections.

No construction has been begun between Scollay square and Hanover street, and none between Haymarket square and Causeway street. Taking it as a whole, about 29 per cent. of the entire subway has been completed, and about 37 per cent. more is under contract or ordered to be done directly by the Engineering Department.

In this connection it may be well to quote from last year's report:

"The Commission has constantly kept in view the fact that it costs but comparatively little to change plans while

they exist on paper only, but that it is difficult, and entails waste of money, to change such plans after they have been embodied in masonry and steel. There are conditions about the subway work that are somewhat novel and demand thorough study in order to ensure a satisfactory solution. Having these facts in mind, a great deal of time has been spent in making studies to determine the routes to be taken and the best and most convenient ways of arranging tracks at the stations and terminals, with the object of handling in the most convenient manner the largest amount of traffic."

In exemplification of the foregoing it may be stated that about seventy studies have been made for the Causeway-street station and connections therewith.

Sketches indicating ten of these studies are shown on Plate 1.

A few of the studies for the routes between Haymarket square and Scollay square are indicated on Plate 2.

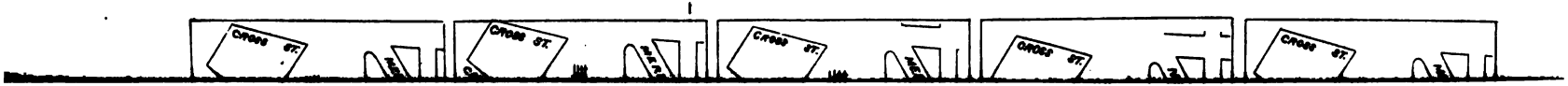
CROSS-SECTIONS OF THE SUBWAY.

The cross-sections adopted in different parts of the subway are described and illustrated in the detailed reports of the different contract sections. They are of two distinct types. One, the masonry arch type, has a roof consisting of an arch with its axis parallel to the subway, and having both arch and side-walls composed almost entirely of masonry. The other, the steel and masonry combined type, has a roof supported by steel beams running at right angles to the axis of the subway, the side-walls being of steel posts with concrete around and between. The merits and demerits of both types were discussed at considerable length in last year's report. The masonry arch type is employed in Sections 4 and 6 in Tremont street, where the traffic is great and space on the street very valuable. One advantage of this type mentioned in last year's report is that it can be constructed by piecemeal, and all the materials for it can be conveniently sent from above the surface to the work below through much smaller holes than would be required for placing long and heavy roof I-beams such as are required in the combined type.

METHODS EMPLOYED IN THE CITY STREETS.

As the city streets are at times not sufficiently ample for their normal traffic, it is evident that as little interference with them should be made in carrying on our work as is consistent with economy and reasonable expedition.

Before deciding on methods to be employed in construct-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CROSS ST.
CROSS ST.

ing the subway under the streets of Boston, some of the methods were examined that have been used for similar work elsewhere.

Work under Cannon Street, London.

The method employed in building that part of the inner circle of the Metropolitan Railway under the crowded thoroughfare of Cannon street in the heart of the city of London is interesting. An account of this was given in 1885 to the Institution of Civil Engineers by Mr. Barry, who was joint engineer on this work with Sir John Hawkshaw. The following statement, condensed from Mr. Barry's paper, will illustrate the method there used of preventing undue interference with the traffic in the street.

The first operation was to lay down at night, over such a length of street as could be safely undertaken, cross-timbers running from one side of the street to the other. These were 12 inches by 12 inches and placed 4 feet apart. Upon them were laid 4-inch planks longitudinally with the roadway, and, on the top of these, 3-inch planks at right angles to the roadway.

When a sufficient length of this plank roadway had been completed, an area about 10 feet wide and about 50 feet long (called a hoarding) was fenced off on it, in which a portable steam crane was used so as to be able to fill carts at either end of the enclosure.

The next operation was to dig a trench about 10½ feet wide under this bridge lengthwise of and in the centre of the street, and from it cross-trenches to the vault walls under the curbstones. The walls of the buildings were then underpinned. When this operation was completed the main trenches for the side walls and the sewer were undertaken.

These large trenches, about 9 feet wide, involved very considerable rearrangements of the timbering, in order to support the vault walls, the roadway, and the gas and water pipes, while leaving a free space for the execution of the trenches. These main trenches were then filled with concrete, the sewers were built, and everything was prepared for the setting of the centres.

This again involved new alterations of the timbering to leave a space free for the turning of the arch of the covered way in lengths of 12 feet.

Brick piers were carried up from the backing to support the large gas and water mains, which during the progress of the excavations had up to this time been propped by temporary expedients on the timbering. The dumpling, or

earth included between the walls and the arch, was then removed, and the invert was inserted in lengths of 12 feet, the walls being well braced until the invert was hard.

The earth was finally filled in over the arch between the timbers, and was allowed to settle below the timbers and planking for a considerable time. At last, when the earth seemed well consolidated, the timbers and planks were removed in lengths and the streets repaved, one-half of the roadway being always available for traffic during repaving.

Some points of resemblance and of difference between this and the method used on much of our work in streets are noted further on.

The Greathead Method.

Although Mr. Greathead may not have invented the method to which his name is frequently applied, he has done much more to exemplify its use than any one else. This method involves the use of a metal circular tube, called a shield. The advanced or head end of the walls of the tunnel are built inside the rear end of the shield which envelops these walls for a short distance like a skin. As excavation is made the shield is pushed forward, — the jacks for this pushing reacting against the end of the walls of the tunnel and against a rib or diaphragm inside the shield. The rear end of the shield, before it is pushed forward, may overlap the end of the tunnel to the extent of, say, two or three feet, and after this movement only a few inches. After this advance the walls of the tunnel are constructed for a distance equal to the advance. The shield thus serves to hold up the earth for a few feet in advance of the permanent walls of the tunnel. The earth as excavated is carried to the rear from the advance end of the shield through the bore of the shield itself and through the bore of the tunnel, and at some convenient place is hoisted by means of a shaft to the surface. One advantage of the use of this method is that the surface of the ground is not disturbed at all under favorable circumstances, except at the shafts where the shields and masonry material are put in and where the earth is taken out. The deep dry bed of clay underlying the metropolis of London is extremely favorable for this process. In soft, water-bearing material, however, where it is necessary to use compressed air, considerable, and in some cases serious, disturbances of the surface have sometimes occurred. In the portion excavated this summer of the projected tunnel under the Spree, between Treptow and Stralau, Berlin, considerable settlements took place on the

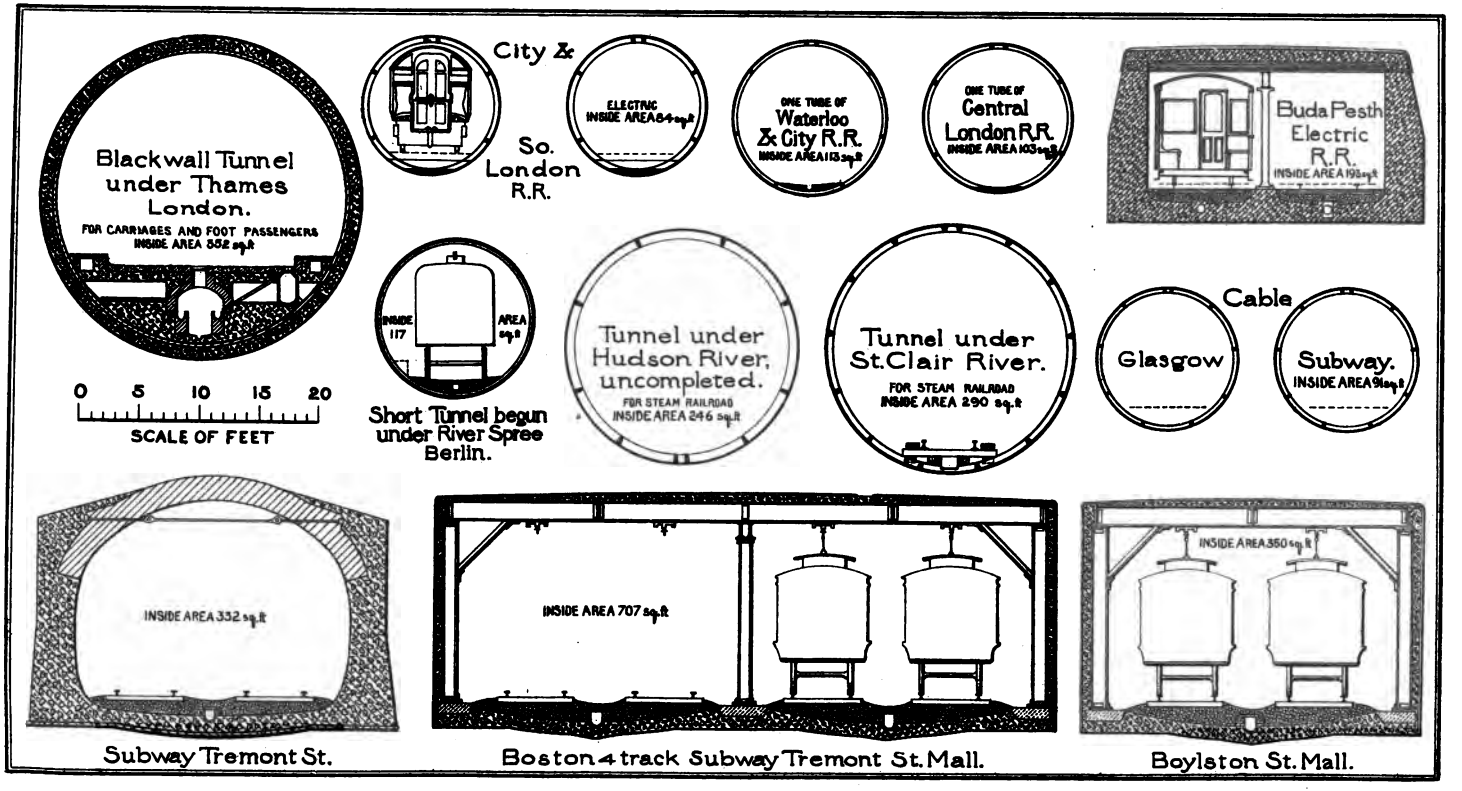


PLATE 3. RELATIVE SIZES OF VARIOUS SUBWAYS.

surface. A blow-out occurred last year from the 11-foot circular tunnel which was being driven under the Yarra River, near Melbourne, Victoria, by which six men were killed.

Ninety-five per cent. of all the tunnelling by this method has been for sizes much too small to admit of the passage of a Boston street-railway car. The most famous use of it was in the construction of the City & South London Railway tunnels, which have internal diameters of 10 feet 3 inches for part of their length, and of 10 feet 6 inches for the remainder. The tunnels for the Glasgow cable subway have internal diameters of 11 feet; those for the Waterloo & City Railway in London, now nearly completed, have for their ordinary sections internal diameters of 12 feet $1\frac{3}{4}$ inches. The tunnels for the Central London Railway from Shepherds Bush to Liverpool-street station, work on which has recently begun, will have internal diameters of 11 feet $8\frac{1}{4}$ inches. The projected Hammersmith & City Electric Railway tunnels in London will have internal diameters of 11 feet 6 inches. That under the Spree at Berlin, alluded to above, has an internal diameter of about 12 feet 8 inches. Three short tunnels of larger size under rivers have been made by this method, two of which are decidedly smaller than even the two-track portion of the Boston subway. The last built and largest of the three is the Blackwall tunnel under the Thames, in London. This is circular in section, and has an internal diameter of 24 feet 3 inches. The contract for this work contemplated doing by the shield method all excavation having a depth of more than 40 feet from the surface, but the contractors, although they had had extended experience in the use of the shield method, preferred to, and did, do their excavation by open trench until a depth of 65 feet was reached.

Plate 3 shows the relative sizes of cross-sections of the Boston subway, of most of the structures alluded to in the foregoing paragraphs, and of the Budapest subway.

A considerable part of the Boston subway is a 4-track structure, while another considerable proportion consists of stations. These stations are placed with their roofs just under the surface of the ground, so that stairways will be short. This involves coming very close to the pipes and sewers, many of which are in fact laid in the roof of the subway itself. Where branches occur, in order to avoid grade crossings sub-subways have been built passing under the subway proper, and the conditions imposed on the subway by the stations, branches, and by the route of the subway itself, make it a complex structure with frequent changes in

size and character of cross-section. A tunnel built by the Greathead method must employ as many different shields as there are different sizes.

The ideal cross-section of the subway is nearly a rectangle, while all of the tunnels made by the Greathead method have circular cross-sections. Tunnel shields when pushed forward have usually taken upon themselves a rotary motion. This motion causes no inconvenience in a circular section, but would be fatal in a rectangular one. The Greathead method is very valuable for such work as that to which it has been applied in London, Glasgow, and elsewhere, but it could be applied to but little of our present work with advantage. It is probable that a modified shield will be tried on a small portion of the subway work in Boston, and should the East Boston tunnel be built by the Commission, the shield method is one of those available for that work, as was stated in last year's report.

Underground Railways in Glasgow.

In addition to the cable subway in Glasgow (heretofore alluded to), several miles of underground road have been built for feeders to two rival railway systems. The Glasgow City and District Railway, begun in 1883, was completed in 1886. The Glasgow Central Railway was begun in 1889, and was completed this year. The earlier road had a considerable proportion of tunnel, but was partly built by open trench. Only a short portion of the latter road was built by tunnel. In neither road was the shield method made use of, and considerable settlement took place on the surface over the tunnels of both roads. Some portions of these underground roads pass under crowded streets. In building the latter road (the Glasgow Central) especial pains were taken to prevent interference with street traffic in crowded thoroughfares, such as Argyle street. Openings on the street were limited during week-days, according to the contract, to areas 50 feet long and 17 feet wide, and the distance between two consecutive openings was not to be less than 600 feet. Between the hours of 12 P.M. Saturday and 5 A.M. Monday, traffic was shut off from the street entirely at the points where work was in operation. The work during the week was mainly in putting in side-walls and taking out the core where the arch had been completed. On Sundays the surface of the street was torn up in order to put on the roof.

PLATE 4. — TRENCH FOR ARCH OF SUBWAY, BOULEVARD ST. MICHEL, PARIS. December, 1894.

Method used in Constructing the Underground Railway in Paris under the Boulevard St. Michel and Contiguous Streets.

This road was completed about a year and a half ago. Its design and the method by which it was constructed are considered admirable. The first operation was to relay the pipes and sewers on the sides of the street. A temporary paved roadway, including a street-railway track, was then made in each sidewalk, the latter being 22 feet and upwards in width. A trench about 6 feet wide for one side-wall of the subway was then dug, and the side-wall was built therein up to the skewback for the arch. A similar trench for the other side-wall was then dug, and the side-wall itself was built up as before. As soon as the two side-walls were finished the earth between the outside limits of the two trenches was excavated, making a trench nearly 40 feet wide, down to the level of the intrados of the arch. The earth core was then rounded over and covered with thin plaster in order to form a centre for the main arch of the subway, spanning from one side-wall to the other. Plate 4 shows a photograph of this trench, with the earth being rounded over to form the centre on which to turn the arch. The interior core under the arch between the side-walls was removed subsequently. The earth from all these excavations (except such as could be used for backfilling neighboring trenches), as fast as taken out, was carried by means of tip-carts and other vehicles to public dumps. In performing the operations referred to, the street was divided into blocks or sections, 200 to 300 feet long, each section being limited by streets crossing the boulevard. Operations were carried on simultaneously in Sections 1, 3, and 5, those in Sections 2 and 4 being left to a subsequent period, in order not to cause too much inconvenience to the travel on the boulevard. No travel was allowed in the temporary roads in the sidewalk except the street-railway cars and carriages going to buildings in the block in question. The foregoing description applies to the regular 2-track subway. In another portion of the boulevard a station of considerable length, and a portion of the subway with two side-tracks, was built, with a much wider arch. In this case the work was done by piecemeal. The trenches for the side-walls were short, and the main trench was dug wide enough for only half of the arch. This half-arch was turned on an earth centre, and after this trench had been refilled the trench was dug for the other half of the arch.

Underground Electric Railway in Budapest.

Budapest has an underground electric railway about two miles in length, which passes under Andrassy street — one of the finest streets in the world — and under other important streets. Work was begun on it in 1894, and it has been finished and put in operation within a few months. This is a double-track subway, with a cross-section much smaller than that of the double-track portion of the Boston subway. The construction of the roof, which lies very close to the surface of the street, is similar to that used on a considerable part of the Boston subway; its side-walls are concrete. The excavation was done by open cut, travel being shut off from the portions of the street where excavation was going on. Plate 5 shows an end view of some of the finished work on Andrassy street. In the background of the picture a portion of the plant is seen where work is going on, and a fence across the street shutting off travel. Plate 5a exhibits work on the station in Andrassy street in front of the Opera House.

Underground Railway in Baltimore.

The Baltimore Belt Railroad is built under Howard street, one of the important streets of Baltimore, for a distance of something over a mile and a half. Most of this was constructed by tunnelling, and is wide enough for a double-track steam railway. Electric locomotives are employed to some extent to haul trains through, including the steam locomotives attached to such trains. In constructing this tunnel considerable settlements of the earth took place in the vicinity of the tunnel, causing breakages in water-pipes and sewers, and injuring some houses so seriously that they were taken down. An attempt was made on a portion of the work to use a shield for the upper arch, but the attempt was unsuccessful. It may be mentioned here that according to "Le Génie Civil" (a Paris technical journal) a somewhat similar shield has been used to some extent this spring in Paris in constructing a sewer. The cross-section of this shield, instead of being a complete circle, as in those used by the Greathead method, is a semi-ellipse.

Methods of Constructing the Subway in the Streets of Boston. — The Slice Method.

This name is used because it is a descriptive one. The method has been varied considerably in detail, depending on the amount and importance of the traffic in the par-

PLATE 5. — BUDAPEST SUBWAY. VIEW ON ANDRASSY STREET.

PLATE 5a. — ROOF FOR OPERA-HOUSE STATION, UNDER ANDRASSY STREET, BUDAPEST SUBWAY.

ticular part of the street in question. The following slightly modified extract from the specifications for Section 4 describes it:

"Trenches about 12 feet wide shall be excavated across the street to as great a distance and depth as is necessary for the construction of the subway. The top of this excavation shall be bridged by strong beams and timbering, whose upper surface is flush with the surface of the street. [These beams usually consist of hard-pine 10 inches by 8 to 12 inches, 20 feet long, placed side by side lengthwise of the street. Two or more 6-inch I-beams are used for supporting each rail of the street railway. The ties of the railway are usually under these beams and fastened to them with bolts. The surface of the beams are covered with plank, precisely flush with the paving of the street.] These beams shall be used to support the railway track as well as the ordinary traffic. Portions of the bridging can be removed day and night in accordance with the provisions of Article C. In each trench a small portion, or *slice*, of the subway shall be constructed. Each slice of the subway thus built is to be properly joined in due time to the contiguous slices. The contractor shall at all times have as many slice-trenches in process of excavation, in process of being filled with masonry, and in process of being backfilled with earth above the completed masonry, as is necessary for the even and steady progress of the work towards completion at the time named in the contract."

The method is such as not to disturb the street-railway tracks at all, and leaves the whole surface of the street, if so desired, in the daytime, entirely free for its normal traffic.

On Section 6, between Park street and Scollay square, the whole width of the street is required to be kept open for regular traffic in the daytime, except that a number of small shafts, each about 6 feet long lengthwise of the street and about 4 feet wide, are used for hoisting, — the earth excavated being carried on overhead railways to Court square and other places, where it can be dumped into carts without interference with traffic.

On a considerable part of Section 6 the slice method is modified by driving a tunnel on each side of the street, in which are built the side-walls of the subway. This, of course, lessens the amount of excavation to be done in the slices. In the part of Section 6 between School street and the middle of the Granary burying-ground *all* of the work will be done by tunnelling, if that shall prove to be practicable.

On Section 4, south of Boylston street, the contractor is given more liberty than on Section 6. In the daytime two-

thirds of the width of the street between curbs is open for traffic, including both lines of street-railway tracks. After 7 o'clock in the evening only one line of railway track is open for traffic and one-third of the width of the street. Between 11.30 P.M. and 6 A.M. the traffic on both lines of railway track is shut off, but the street is kept sufficiently open to allow fire-engines to pass anywhere lengthwise through the streets and into and out of adjacent streets.

It will be seen that the slice method used, with various modifications, on our work has this in common with the method used on Cannon street, London, that the street surface is bridged over where excavation is going on by heavy beams and timbers. In some parts of our work, too, the hoisting-apparatus is placed on the surface of the street, as was the case on Cannon street; but in the most important part, and that which most closely resembles Cannon street, conveyors are placed over the sidewalks at such a height as not to interfere with the traffic, and the earth is carried to points where there is comparative freedom from congestion.

Notwithstanding the resemblances between the Cannon-street and the slice methods of timbering, the results of the two are quite different. The slices are numerous and narrow. In Cannon street there was only one place of excavation at a given time, and that, measured lengthwise of the street, was wide. The narrow width of the slices results in the street bridges being very simple and strong, no props being required; it also allows the pipes to span the trenches without props. No rearrangement of the timbering is necessary. By the Cannon-street method the street bridges and the pipes both required numerous props, and at two stages of the work very considerable rearrangements of timbering were required.

In Cannon street there was no street railway; in Tremont street a double-track railway service has been constantly maintained during the day, some of the cars when very heavily loaded with passengers having a weight of nearly eighteen tons.

In Cannon street the walls of the buildings were underpinned. Although the walls of the Boston subway extend to a considerable depth below the foundations, it has not been deemed necessary or expedient in most cases to underpin the latter. Underpinning is a costly and extremely slow process, and causes more inconvenience to occupants of adjacent buildings than building the subway itself. By opening a sufficient number of slices progress can be made as rapidly as is desired within certain limits.

Debits for Street Occupancy.

The following is an extract from the contract for Section 6:

"The contractor shall be debited one cent (1c.) per day of twelve hours for each square foot of surface that he occupies (or by his act or neglect leaves unavailable for public use) between the hours of 7 A.M. and 7 P.M. in accordance with the provisions of this contract, and a proportionate sum for any less time. If he occupies surface in violation of the provisions of this contract, he shall be debited at the rate of six cents (6c.) per square foot per day of twenty-four hours, and a proportionate sum for any less time."

Other penalties for violating the contract are not waived.

Substantially the same clause with different rates has been adopted in other contracts for the subway under public streets. It is a natural and well-known practice of contractors to spread their tools and débris over a large surface, greatly to the annoyance of abutters and the public generally. By the debit system the contractor is encouraged to plan his work so as to occupy only a small area, and that but for a comparatively short time.

SURFACE AND UNDERGROUND SURVEYS. — PLANS.

Nearly all of the necessary surveys were made last year. Some additional ones, however, have been made near the junction of Tremont street and Shawmut avenue, and some in Hanover street and Haymarket square. Excavations have been made to determine the foundations of buildings in Hanover street and in Scollay square.

Borings were made in all portions of the subway route last year, and were alluded to in last year's report. Additional borings have been made for the year ending August 15, 1896, as follows:

Thirteen Borings for East Boston Tunnel.

	Feet.
Minimum depth	19.5
Average depth	39.7
Maximum depth	80.5
Total amount	516.8

Forty-four Borings for the Subway.

	Feet.
Minimum depth	15.5
Average depth	29.86
Maximum depth	55.5
Total amount	1314.0

Fifty trial borings have been made in connection with these, of an average depth of 12 feet each.

Samples have been taken at depths from 1 to 8 feet apart, averaging 4 feet.

Four of the subway borings have been made on Tremont street, near Common street, sixteen in and near Washington street from Elm street to Merrimac street, on account of underpinning buildings, and ten have been made on Tremont street between Park street and School street, to determine the character of the ground composing the roof of the proposed tunnel portion of Section 6.

A test well to determine the level of ground water has been sunk at each of the following places: Devonshire street, corner of Dock square; Washington street, corner of Elm street; Washington street, corner of Hanover street; Washington street, corner of Merrimac street. The average depth of these four wells was 19 feet.

Fifty trenches across streets have been dug to determine pipe and sewer locations.

About 1,400 plans have been made during the year. These have been principally contract and detail plans for construction, but the number includes also studies and designs.

CEMENT.

There have been used during the year approximately 30,000 barrels of Portland cement, mostly of German, but partly of American manufacture, and 1,050 barrels of Rosendale cement.

Numerous excellent brands of Portland cement are now made in different parts of the world. It has been thought prudent to select from these brands with which long experience has been had in actual work. Slow-setting and quick-setting Portlands have been used respectively as the Engineer thought necessary. They have been tested as to fineness of grinding, specific gravity, etc., and their products have been tested as to tensile and crushing strength, setting, cracking, and other qualities. Records of these tests were accessible to the contractors. About 8,500 briquettes have been made during the year ending with this date (August 15). About 50 per cent. of these briquettes have been mixed with the same proportions of cement and sand as were used in the mortar on the work. Some of the briquettes have been made with a small proportion of water (about 13 per cent. by weight), and rammed into the moulds, but the larger proportion have been made with about the volume of water used in mortar, that is to say, about 20 per cent.

The sand used has been a standard sand from Plum Island, in which all grains that would not pass through a sieve having 400 meshes to the square inch, and all which would pass through a sieve having 900 meshes to the square inch, have been thrown out. Tests have also been made with crushed quartz and with crushed granite.

In addition to the briquettes made from sampled cement, briquettes have also been made daily from mortar taken from the boxes of the contractors as it was being made for actual use on the work. Briquettes have been broken at various ages, from one week to two or more years. The larger proportion have been broken when a week old. About 150 concrete beams 6 inches square and 6 feet long have been made. Some of these beams were kept in tanks of water, and some were kept in damp sand. Most of the beams of concrete were broken when 30 days old.

SURPLUS EARTH.

The disposal of surplus earth, equal in volume to the displacement of the subway, is a matter of importance. As is stated elsewhere, the surplus earth from Section 1 and a considerable part of that from Sections 2, 3, and 3½, has been used for bringing some low portions of the Public Garden and of the Common to more desirable levels. Most of that from Section 4 has been disposed of by the contractor for filling in near the new Southern Union Station and at other places. A considerable part of that from Sections 6 and 10 has been loaded by the Commission on Boston & Maine railroad gravel-cars. This earth has been hauled away at night without charge to the city. To arrange for loading the cars a bridge or elevated roadway has been carried across and above the tracks between Haverhill street and Canal street. The dump-carts ascend this bridge by an incline on Haverhill street and cross the tracks, discharging the load in any one of the six trap-doors to gravel-cars beneath, and then descend by an incline along Canal street. About 60 to 70 gravel carloads can be handled per day in this manner. More could be taken away if it was practicable for the trains to go out in the daytime. This is prevented by the express and other teams which stand over the track. Some earth has been carried to the new Cambridge park, some to Russia wharf, and some to other places.

CONSTRUCTION.

Detailed statements of the work on the contract and day-work sections are given in the following pages. They are in a large measure compiled from the reports of Assistant Engineers Edwards, Shepherd, O'Brien, Marden, Palmer, and L. H. Davis.

WORK DONE ON SECTION 1 OF THE SUBWAY FOR THE YEAR ENDING AUGUST 15, 1896.

For the sake of completeness and to save reference elsewhere some facts in regard to this section that were stated in the first annual report are here repeated:

Location. — Three hundred and eighteen feet open inclined entrance in the Public Garden, beginning opposite Church street and running towards Charles street.

Six hundred and eighty-five feet of two-track subway from end of open incline to a point in Boylston-street mall of the Common opposite the old Public Library building.

Four hundred and eight feet of four-track subway in Tremont-street mall of the Common, from about 170 feet north of Mason street to near West street.

The contract originally included, in addition to the above, 60 feet of four-track subway, near Mason street. On account of making the station near the intersection of Boylston and Tremont streets larger than first contemplated, this length was taken from Section 1 and in a modified form included in the contract for Section 2.

Contractors for Steel Work. — THE PENNSYLVANIA STEEL COMPANY, Steelton, Pa.

Contractors for Construction. — JONES AND MEEHAN, Jamaica Plain, Mass. MR. MEEHAN, of this firm, has acted as superintendent.

City Assistants.

F. B. EDWARDS, Assistant Engineer.
G. H. FOSS, Jr., Assistant on Construction.
WILLIAM PARK, Inspector of Masonry.
W. A. GOULD, Assistant on Construction.
G. M. BACON, Transitman.
W. E. WATKINS, Rodman.

Bids and Contracts. — Bids for the steel-work were opened March 9, 1895, and contract was signed March 23. Bids for construction were opened March 20, 1895; contract was signed March 23.

Condition of Work, August 15, 1895. — The open incline was completed with the exception of a few cubic yards of granite in the side-walls.

Ninety-six feet of the two-track subway had been completed and, in addition, 42 feet of masonry invert, 24 feet of side-walls, 42 feet of steel structure, about 30 feet of excavation near Charles street, about 20 feet of excavation near old Public Library building, and about 400 feet of trench excavated 14 feet deep along Boylston-street mall.

Of the four-track subway, from the end opposite West street, a trench 190 feet long and 10 feet wide had been excavated to grade along the line of the easterly side-wall; a similar trench 130 feet long was excavated along the line of

PLATE 6. — SECTION 1, BOSTON COMMON, BOYLSTON-STREET MALL. ERECTION OF STEEL-WORK OPPOSITE BOYLSTON PLACE. October 28, 1895.

PLATE 7. — SECTION 1, BOSTON COMMON. TWO-TRACK SUBWAY UNDER BOYLSTON-STREET MALL.
April 13, 1896.

the westerly side-wall. In these trenches a portion of the masonry invert was constructed and 26 footing-stones set.

The pump-well in the Public Garden was constructed to the level of the adjoining invert of the subway.

Completion of Work. — Work was continued, although at times very slowly, from the beginning of the year to the substantial completion of the contract, May 22, 1896.

Material Used in Constructing Section 1.

911 tons of steel.
768 cubic yards brick masonry.
8,179 cubic yards concrete masonry, Portland cement.
179 cubic yards concrete masonry, American cement.
816 cubic yards granite masonry.
9½ M. feet lumber.
40,304 linear feet piles.
194 cubic yards granite footing-stones.
9,451 square yards water-proofing.

Structures. — A general description of the structures was given in the first annual report. Their positions with relation to the rest of the work can be seen on the progress map at the beginning of this report.

Method of doing Work. — The general method of excavating was the same as that used last year; viz., the shovelling of earth into carts by laborers, and hauling direct to the dump, until a depth of about 10 feet below the surface had been reached. The remainder was shovelled into skips, lifted to the surface, and dumped into carts by means of fixed and movable derricks. Each derrick was operated by a steam hoisting-engine.

The plan first used in excavating for the four-track subway was to make three trenches, each about 10 feet wide, one for each side-wall and one for the centre line of posts, removing the cores after the side-walls and roof had been completed.

It was, however, found practicable to make all the excavation in one open cut, bracing the banks against each other across the trench (55 feet wide), and most of the four-track work was excavated in this manner.

Near Charles street, for a length of about 75 feet, the excavation for the last 10 feet in depth was in stiff blue clay.

Easterly from this clay the bottom, for about 100 feet, was in coarse gravel filled with water. This was drained by a vitrified pipe laid below the masonry invert conducting the water to the pump-well in the Public Garden. After the work was completed, this and all other temporary sub-drains were plugged. With the above exception the material excavated was gravel, coarse and fine sand, in which there was no water.

A large proportion of the sand and gravel used in the work for concrete, etc., came from the excavated material.

On Plate 6 is a photograph taken during construction on Boylston street, near Boylston place. Plates 7 and 8 give views of the interior of the two-track and of the four-track subway.

Water-proofing. — In most of the invert of the two-track subway lying below ground-water level (about elevation 110) a 4-inch course of concrete was laid below the regular masonry invert. This course was covered with a layer of asphalt extending laterally so as to meet the asphalt on the outside of the side-walls.

The outside of the side-walls was plastered next the concrete, with Portland cement mortar A coating of asphalt was then applied to the entire surface of the plaster and continued over the roof. As an additional precaution, aimed especially to keep the steel dry, a vertical course of ribbed tile was carried up against the asphalt on the side-walls to the height of ground water level. Against the outside of this tile was laid a course of brick masonry covered with asphalt.

On each side, every 6 feet, a 2-inch vitrified pipe was laid through the side-walls connecting the bottom of the ribbed tile with the inside of the subway, forming a free outlet for any ground water that might find its way into these interior spaces.

A pump chamber, constructed of steel and concrete masonry, was built in the Public Garden over the pump-well, a description of which will be found in the first annual report.

An 18-inch pipe drain 445 feet in length was laid from this pump chamber to the Church-street sewer in the Public Garden. On this drain are three manholes, in one of which is an automatic gate to prevent the back-flow of water.

In the four-track subway, 192 feet southerly from West street, there is a valley in the grade. To provide drainage from this valley a 15-inch vitrified pipe was laid in concrete below the invert, to the Mason-street end of the work.

This drain will be continued through Sections 2 and 4, to a pump chamber to be built at the intersection of Eliot and Tremont streets.

Ventilation. — A chamber made of Portland concrete masonry was constructed just east of the Central Burying Ground in the Common, large enough for a 7-foot fan and the necessary motor to operate it. The chamber has a 6½-foot circular masonry air duct curving upward and ending at the present time near the surface.

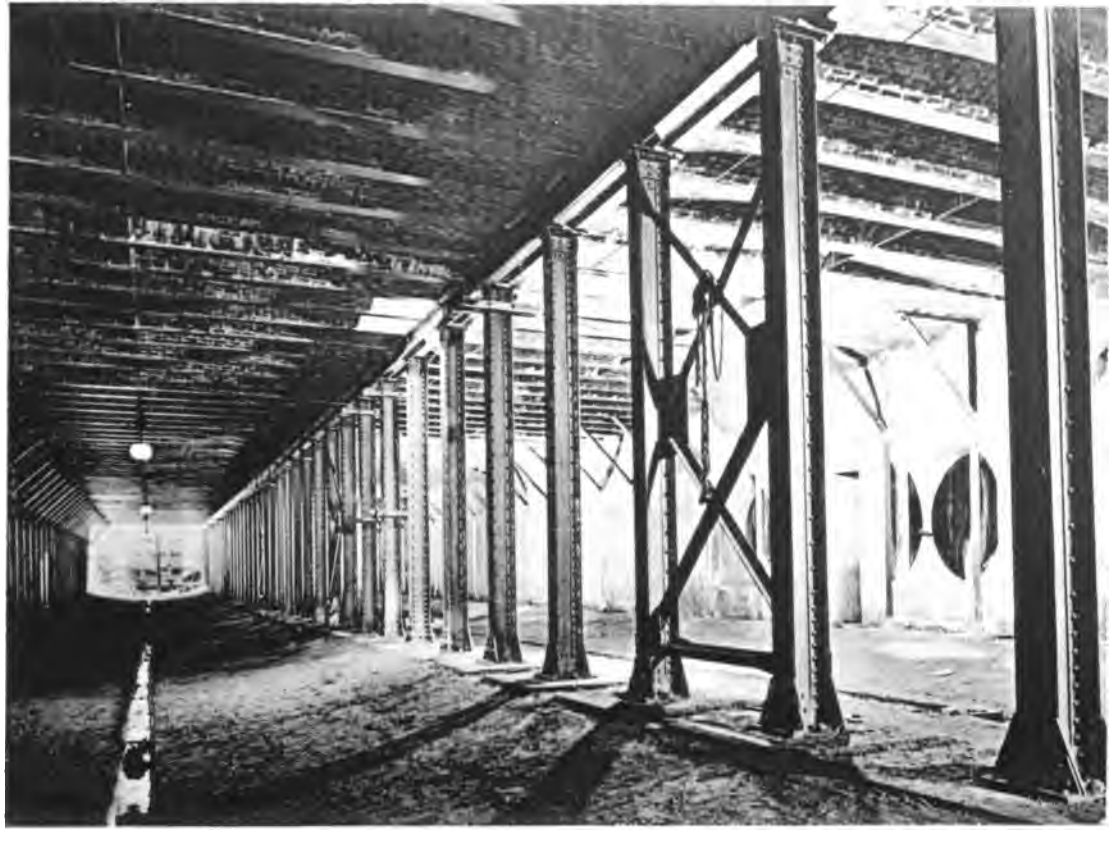


PLATE 8. — SECTION 1, BOSTON COMMON. FOUR-TRACK SUBWAY UNDER TREMONT-STREET MALL. OPENING FOR VENTILATING CHAMBER ON THE RIGHT.

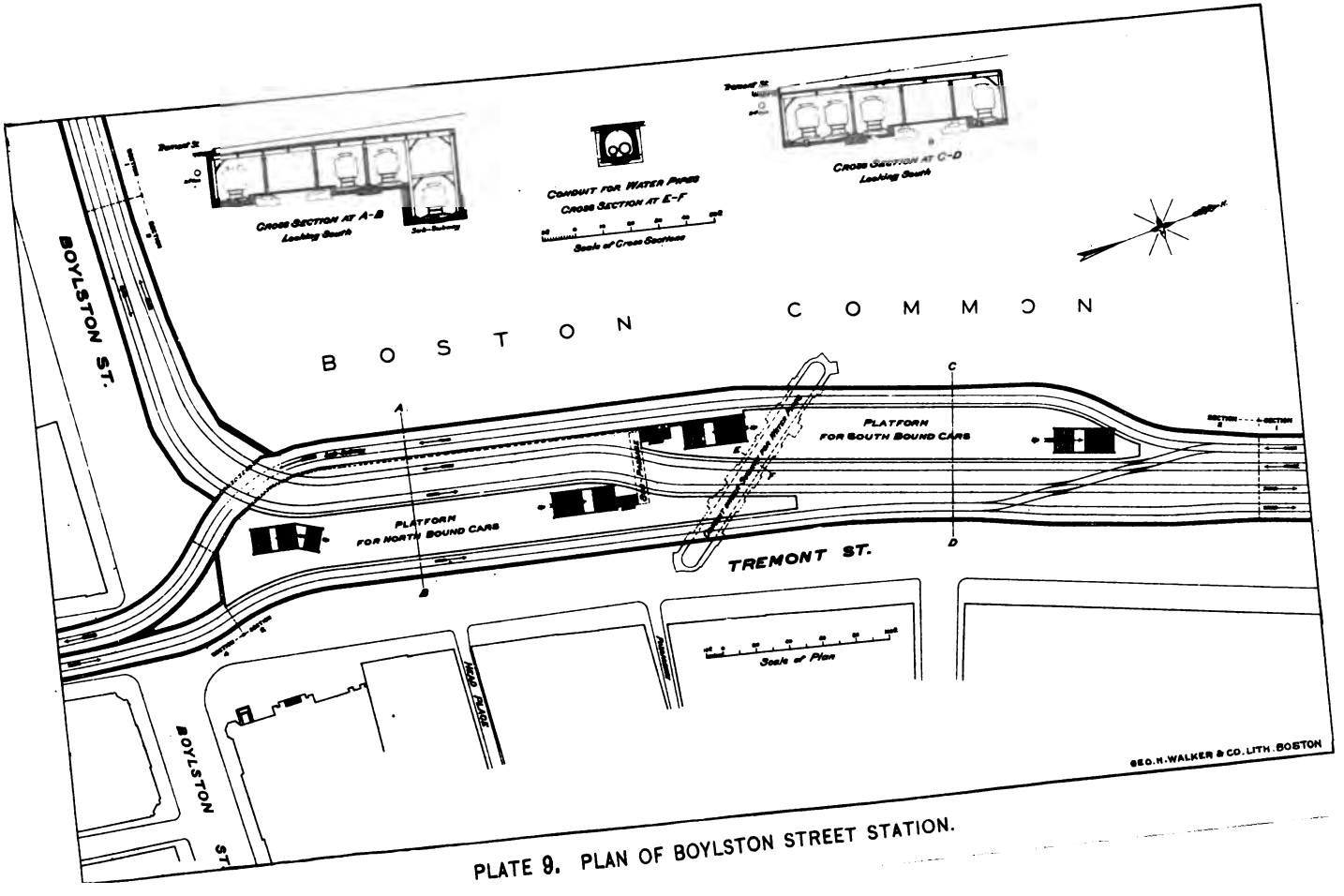


PLATE 9. PLAN OF BOYLSTON STREET STATION.

PLATE 7. — SECTION 1, BOSTON COMMON. TWO-TRACK SUBWAY UNDER BOYLSTON-STREET MALL.
April 13, 1896.

the westerly side-wall. In these trenches a portion of the masonry invert was constructed and 26 footing-stones set.

The pump-well in the Public Garden was constructed to the level of the adjoining invert of the subway.

Completion of Work. — Work was continued, although at times very slowly, from the beginning of the year to the substantial completion of the contract, May 22, 1896.

Material Used in Constructing Section 1.

911 tons of steel.
768 cubic yards brick masonry.
8,179 cubic yards concrete masonry, Portland cement.
179 cubic yards concrete masonry, American cement.
816 cubic yards granite masonry.
9½ M. feet lumber.
40,304 linear feet piles.
194 cubic yards granite footing-stones.
9,451 square yards water-proofing.

Structures. — A general description of the structures was given in the first annual report. Their positions with relation to the rest of the work can be seen on the progress map at the beginning of this report.

Method of doing Work. — The general method of excavating was the same as that used last year; viz., the shovelling of earth into carts by laborers, and hauling direct to the dump, until a depth of about 10 feet below the surface had been reached. The remainder was shovelled into skips, lifted to the surface, and dumped into carts by means of fixed and movable derricks. Each derrick was operated by a steam hoisting-engine.

The plan first used in excavating for the four-track subway was to make three trenches, each about 10 feet wide, one for each side-wall and one for the centre line of posts, removing the cores after the side-walls and roof had been completed.

It was, however, found practicable to make all the excavation in one open cut, bracing the banks against each other across the trench (55 feet wide), and most of the four-track work was excavated in this manner.

Near Charles street, for a length of about 75 feet, the excavation for the last 10 feet in depth was in stiff blue clay.

Easterly from this clay the bottom, for about 100 feet, was in coarse gravel filled with water. This was drained by a vitrified pipe laid below the masonry invert conducting the water to the pump-well in the Public Garden. After the work was completed, this and all other temporary sub-drains were plugged. With the above exception the material excavated was gravel, coarse and fine sand, in which there was no water.

A large proportion of the sand and gravel used in the work for concrete, etc., came from the excavated material.

On Plate 6 is a photograph taken during construction on Boylston street, near Boylston place. Plates 7 and 8 give views of the interior of the two-track and of the four-track subway.

Water-proofing. — In most of the invert of the two-track subway lying below ground-water level (about elevation 110) a 4-inch course of concrete was laid below the regular masonry invert. This course was covered with a layer of asphalt extending laterally so as to meet the asphalt on the outside of the side-walls.

The outside of the side-walls was plastered next the concrete, with Portland cement mortar A coating of asphalt was then applied to the entire surface of the plaster and continued over the roof. As an additional precaution, aimed especially to keep the steel dry, a vertical course of ribbed tile was carried up against the asphalt on the side-walls to the height of ground water level. Against the outside of this tile was laid a course of brick masonry covered with asphalt.

On each side, every 6 feet, a 2-inch vitrified pipe was laid through the side-walls connecting the bottom of the ribbed tile with the inside of the subway, forming a free outlet for any ground water that might find its way into these interior spaces.

A pump chamber, constructed of steel and concrete masonry, was built in the Public Garden over the pump-well, a description of which will be found in the first annual report.

An 18-inch pipe drain 445 feet in length was laid from this pump chamber to the Church-street sewer in the Public Garden. On this drain are three manholes, in one of which is an automatic gate to prevent the back-flow of water.

In the four-track subway, 192 feet southerly from West street, there is a valley in the grade. To provide drainage from this valley a 15-inch vitrified pipe was laid in concrete below the invert, to the Mason-street end of the work.

This drain will be continued through Sections 2 and 4, to a pump chamber to be built at the intersection of Eliot and Tremont streets.

Ventilation. — A chamber made of Portland concrete masonry was constructed just east of the Central Burying Ground in the Common, large enough for a 7-foot fan and the necessary motor to operate it. The chamber has a 6½-foot circular masonry air duct curving upward and ending at the present time near the surface.

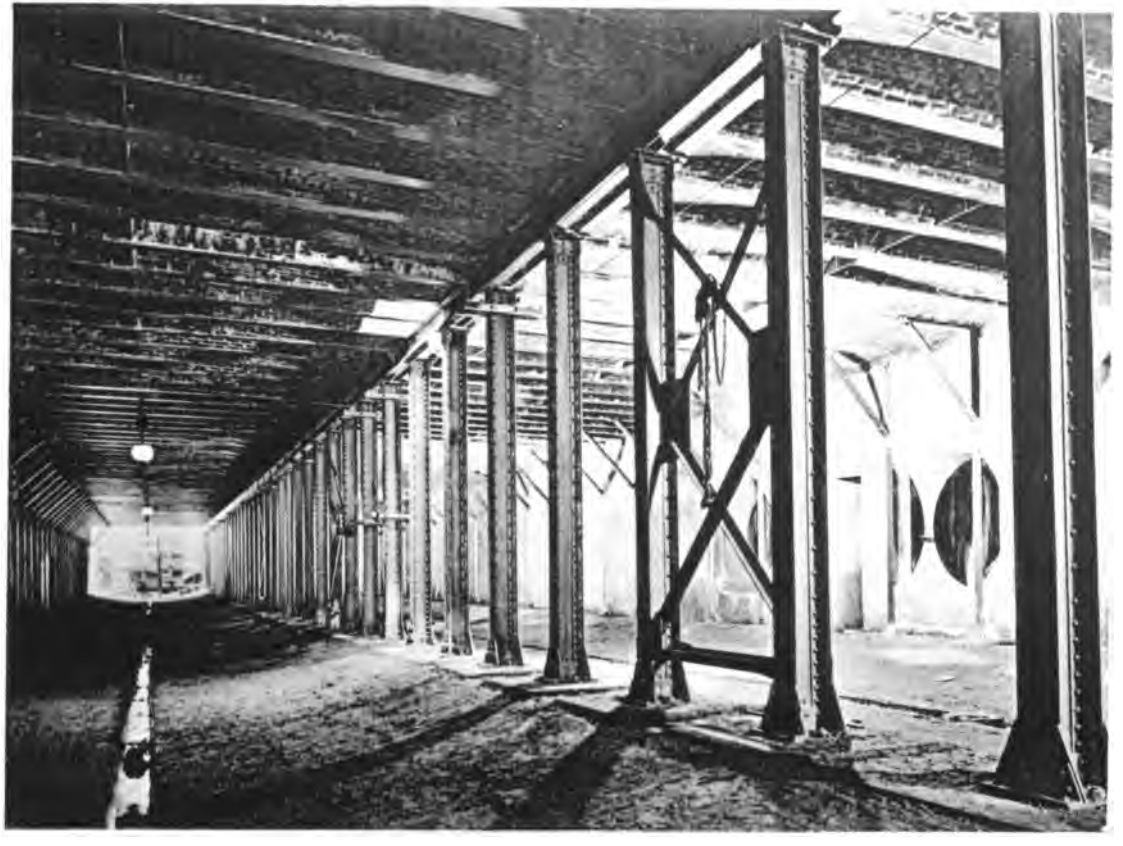


PLATE 8. — SECTION 1, BOSTON COMMON. FOUR-TRACK SUBWAY UNDER TREMONT-STREET MALL. OPENING FOR VENTILATING CHAMBER ON THE RIGHT.
April 24, 1896

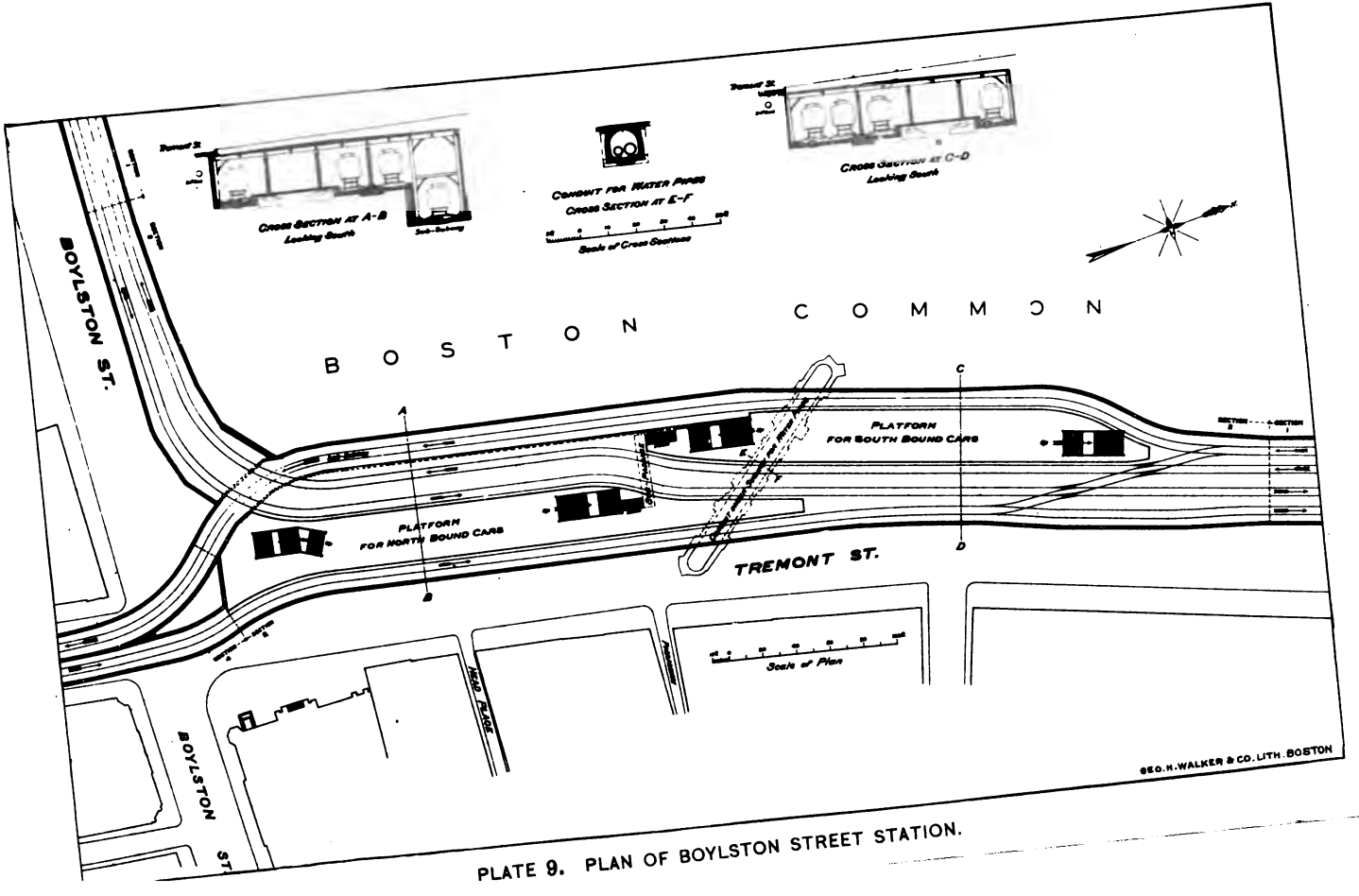


PLATE 9. PLAN OF BOYLSTON STREET STATION.

One hundred and fifty-six feet southerly from West street was constructed a ventilating chamber on the west side of the four-track subway. The side-walls and roof are of steel and concrete masonry construction. It is divided by a concrete wall into two equal parts, each large enough for an 8-foot fan and the necessary motor to operate it. The chamber has an 11½-foot circular masonry air duct.

Pipe Changes. — The building of the subway made it necessary to change the location of several water and gas mains, also catch-basin pipes. These pipes were carried over the subway in specially constructed roof panels, and other such panels were constructed for possible future use.

Surplus Earth, etc. — The surplus earth, except that disposed of by the contractors and used in the masonry, was deposited on the Public Garden and Common.

There were several minor accidents due to laborers and others falling into the trench from the sides and roof.

WORK DONE ON SECTION 2 OF THE SUBWAY FOR THE YEAR ENDING AUGUST 15, 1896.

Location. — Boston Common, corner Tremont and Boylston streets.
Contractors for Steel Work. — THE PENNSYLVANIA STEEL COMPANY, Steelton, Pa.
Contractors for Construction. — EDWARD W. EVERSON, Providence, R.I. J. J. EVERSON, brother to the contractor, superintendent.

City Assistants.

FRANK C. SHEPHERD, Assistant Engineer.
CARL S. DRAKE, Principal Transitman.
WM. O. WELLINGTON, Assistant Transitman.
GEO. M. STEVENS, Rodman.
GEO. M. HAWES, Assistant.
*GEO. H. FOSS, JR., Assistant on Construction.
*CHAS. R. GOW, Assistant on Construction.
*SHERMAN A. JUBB, Assistant on Construction.
*WM. A. GOULD, Assistant on Construction.
WM. PARK, Inspector of Masonry.
*CHAS. P. HORTON, Inspector of Masonry.
*CHARLES F. HALL, Inspector of St ? Erection.

Bids and Contracts. — Bids for the steel-work were opened September 12, 1895, and contract was signed September 13. Bids for construction were opened September 19, 1895; contract was signed September 20.

Structures. — The general shape, dimensions, and position of this section are shown on Plate 9. Its position with relation to the rest of the subway can be seen on the

* Part of time only.

PLATE 7. — SECTION 1, BOSTON COMMON. TWO-TRACK SUBWAY UNDER BOYLSTON-STREET MALL.
April 13, 1896.

the westerly side-wall. In these trenches a portion of the masonry invert was constructed and 26 footing-stones set.

The pump-well in the Public Garden was constructed to the level of the adjoining invert of the subway.

Completion of Work. — Work was continued, although at times very slowly, from the beginning of the year to the substantial completion of the contract, May 22, 1896.

Material Used in Constructing Section 1.

911 tons of steel.
768 cubic yards brick masonry.
8,179 cubic yards concrete masonry, Portland cement.
179 cubic yards concrete masonry, American cement.
816 cubic yards granite masonry.
9½ M. feet lumber.
40,304 linear feet piles.
194 cubic yards granite footing-stones.
9,451 square yards water-proofing.

Structures. — A general description of the structures was given in the first annual report. Their positions with relation to the rest of the work can be seen on the progress map at the beginning of this report.

Method of doing Work. — The general method of excavating was the same as that used last year; viz., the shovelling of earth into carts by laborers, and hauling direct to the dump, until a depth of about 10 feet below the surface had been reached. The remainder was shovelled into skips, lifted to the surface, and dumped into carts by means of fixed and movable derricks. Each derrick was operated by a steam hoisting-engine.

The plan first used in excavating for the four-track subway was to make three trenches, each about 10 feet wide, one for each side-wall and one for the centre line of posts, removing the cores after the side-walls and roof had been completed.

It was, however, found practicable to make all the excavation in one open cut, bracing the banks against each other across the trench (55 feet wide), and most of the four-track work was excavated in this manner.

Near Charles street, for a length of about 75 feet, the excavation for the last 10 feet in depth was in stiff blue clay.

Easterly from this clay the bottom, for about 100 feet, was in coarse gravel filled with water. This was drained by a vitrified pipe laid below the masonry invert conducting the water to the pump-well in the Public Garden. After the work was completed, this and all other temporary sub-drains were plugged. With the above exception the material excavated was gravel, coarse and fine sand, in which there was no water.

PROPERTY
OF THE
BOSTON HERALD
COMPANY

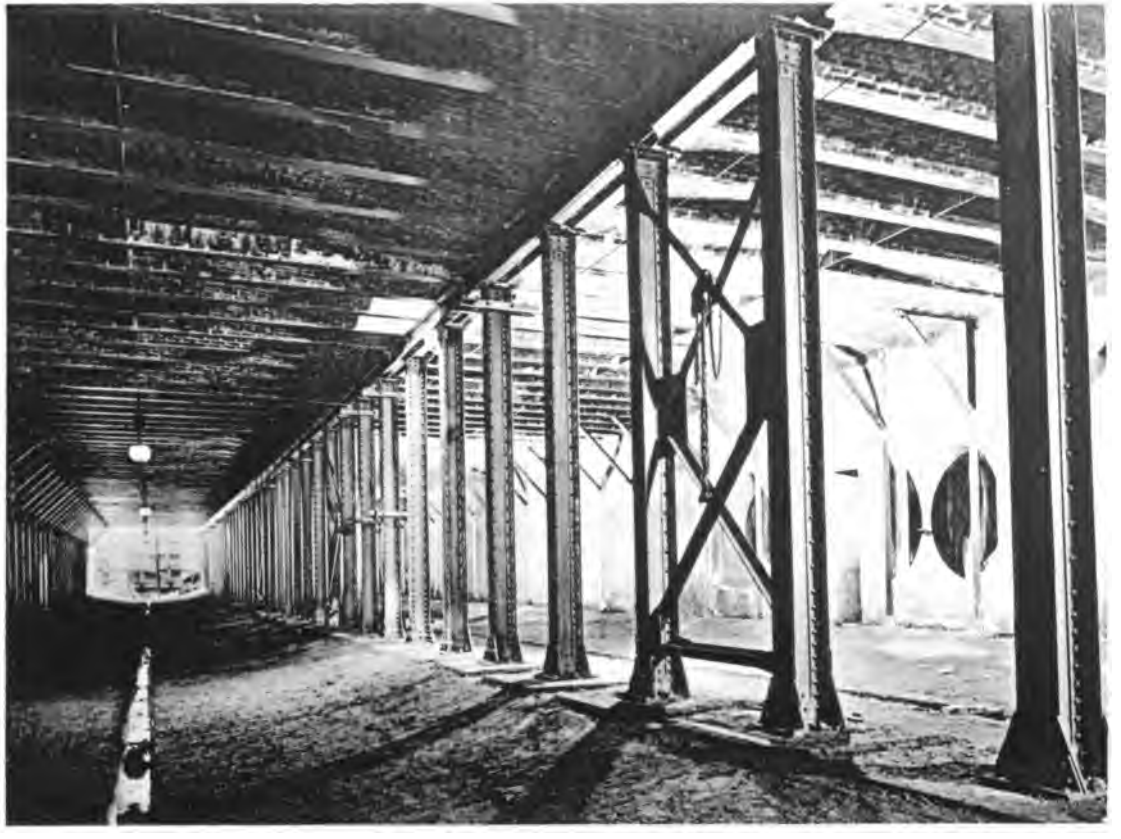


PLATE 8. — SECTION 1, BOSTON COMMON. FOUR-TRACK SUBWAY UNDER TREMONT-STREET MALL. OPENING FOR VENTILATING CHAMBER ON THE RIGHT. April 24, 1896.

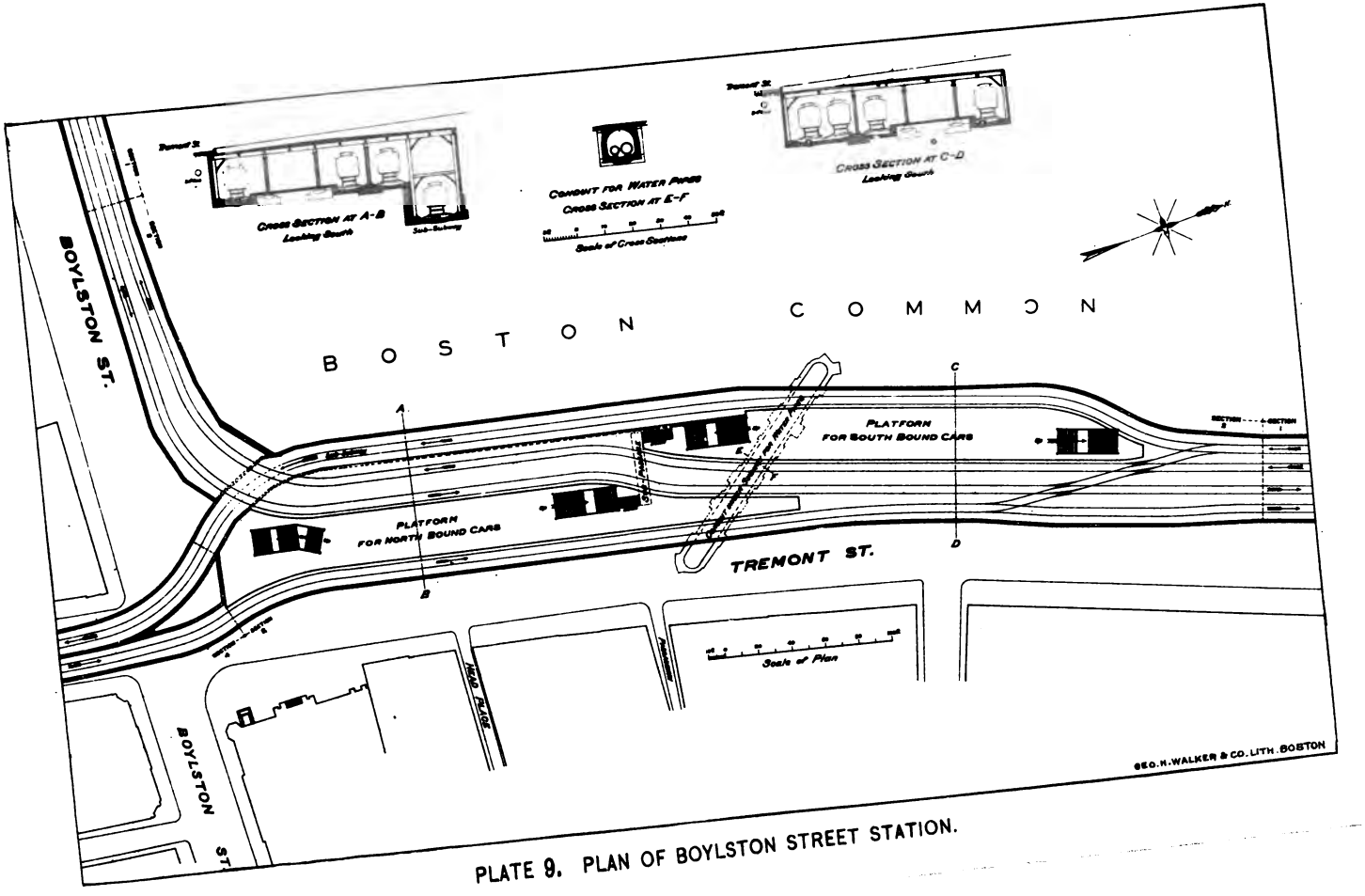


PLATE 9. PLAN OF BOYLSTON STREET STATION.

PLATE 18. — SECTION 3, BOSTON COMMON, TREMONT-STREET MALL. FOOTING-STONES FOR POSTS. OUTLINE OF SOUTH-BOUND PLATFORM. May 29, 1896.

PLATE 19. — STEEL-WORK ON SECTION 3, NEAR WINTER STREET, BOSTON COMMON, TREMONT-STREET MALL. LOOKING SOUTHERLY. July 8, 1896.

PLATE 20. — STEEL-WORK ON SECTION 3, BOSTON COMMON, TREMONT-STREET MALL. July 28, 1896.

Plan. The portion of this section south of St. Paul's church for a distance of about 300 feet consists of a four-track subway having an interior width of from 48 to 60 feet. The remaining part of the section constitutes the so-called Park-street station. It has four tracks and two island platforms. The two platforms are nearly opposite each other, the westerly platform being for south-bound and the easterly for north-bound passengers. The length of the easterly platform is 250 feet, and that of the westerly one 275 feet. They are of irregular shape, each having a width in the middle of its length of upwards of 40 feet. There are two stairways for each platform, each stairway being 15 feet wide. A characteristic of this station is that the two inner tracks terminate in a loop at the northern end of the station. This will enable cars using these tracks, such, for example, as the Brookline and the Brighton cars, to return without switching. A space is provided within the loop for tracks where extra or disabled cars can stand. Pits are provided under these tracks to enable the motors to be taken out or other repairs to be made. The floor and foundations of the station are of concrete. The side-walls and roof are combinations of steel beams and brick and concrete masonry, waterproofed with plaster and asphalt. The combination of materials in this station is similar to that of the Boylston-street station already described.

Excavation. — At Park street, the excavated earth was mainly a firm clayey gravel, but with a stratum one or two feet thick of very fine sand in the middle of its depth. Towards the southerly end of the station the excavation was mainly of a sandy character, in which was a small summit of clay. The material was such as to allow nearly vertical banks to stand for a long time without sheeting. Excavation began November 16. Little machinery was employed, most of the earth being thrown into carts which descended into the pit and ascended therefrom on an inclined roadway. Comparatively little timbering for sustaining the banks was found necessary. In the vicinity of Temple place and south thereof sheeting and bracing was used. All of the excavated earth up to this date (August 15) has been used for grading the Common. A cave occurred on the bank of the excavation on the Tremont-street side, opposite Temple place, about 50 feet in length, on the night of July 24, 1896, during a very heavy rain-storm. Four lengths of a 24-in. gas-pipe, which was not in service, fell into the trench.

Ground-water Drainage. — The volume of water seeking to enter the trench was small in amount, but was enough to cause some annoyance. A system of under-drains was laid to keep this water below the concrete masonry.

Concrete Masonry.— Concrete has been mixed in the proportion of 1 part of cement, 2½ parts of sand, and 4 parts of gravel. The cement used has been mainly the Dyckerhoff Portland.

Progress.

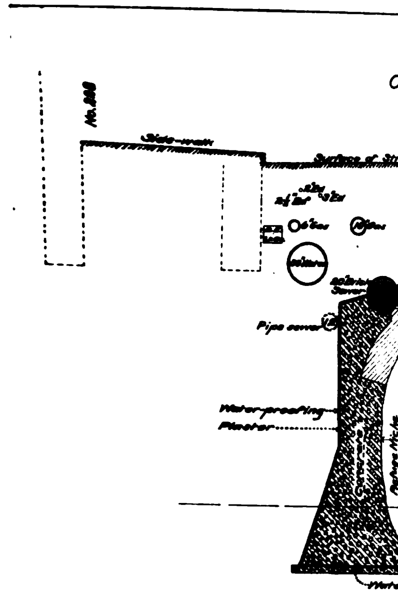
Elements.	Date of beginning.	Average rate of progress per week to August 15, 1896.	Amount completed to date, August 15, 1896.	Total estimated quantities.
		Cubic yards.	Cubic yards.	Cubic yards.
Excavation	November 16, 1895	1,000	35,606	51,000
Concrete invert	April 15, 1896	95	1,730	3,200
Concrete walls	July 18, 1896	40	200	1,200
Concrete on roof	July 23, 1896	61	264	2,600
Brickwork	July 22, 1896	38	151	900
Steel erection	June 12, 1896	51 tons	510 tons	1,350 tons
Footing-stones	May 1, 1896	8	116	350

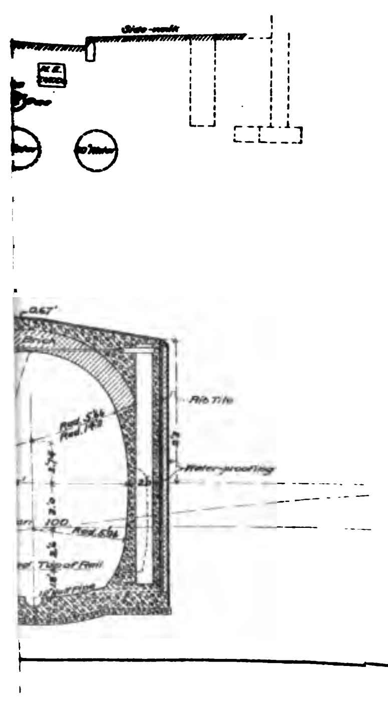
Miscellaneous. — Numerous pipe changes were required in Tremont street to make way for this station. They are referred to in a separate article.

During the process of construction there have been five accidents among the laborers. Two were injured by earth falling on them, while three were injured on steel construction. There were no fatalities.

SECTION 3½.

The section known as 3½ consists of two single-track subways at the foot of Park street, connecting Section 3 with Section 6. It was necessary to change the position of the sewer in Park street to remove it from the space to be occupied by the northerly end of the Park-street station, and as it would necessarily, in its changed position, pass over the location for the subway, it was thought best to build these portions underneath at the time when the sewer change was made. The position of Section 3½ is shown on the Progress Plan. The description on page 53 of the dimensions of the subway near Park-street church and of the branch for the north-bound and that for the south-bound track will suffice for a description of the continuation of these branches, which constitutes Section 3½. In the contract for this section were included the two pieces of single-track subway alluded to above, and about 365 linear feet of pipe-sewer, with seven manholes and catch-basins.


Side-walk
Water-proofing
Plaster
Pipe sewer
Refuge Niche


Side-walk
Rib Tile
Water-proofing
Top of Rail

WORK DONE ON SECTION 4 FOR THE YEAR ENDING AUGUST 15, 1896.

Location. — Tremont street, between the northerly line of Boylston street and the southerly line of Warrenton street.

Contractors for Steel Work. — The New Jersey Steel & Iron Company, Trenton, N.J.

Contractors for Underpinning two Buildings near Common Street. — Isaac Blair & Co., Boston, Mass.

Contractors for Construction. — The Metropolitan Construction Company, Boston, Mass. G. W. Judd has been superintendent.

City Assistants.

F. B. EDWARDS, Assistant Engineer.
G. M. BACON, Principal Transitman.
F. H. MORRIS, Assistant Transitman.
* A. C. LOOTZ, Assistant.
W. E. WATKINS, Rodman.
A. W. TREFRY, Force Accounts and Street Occupancy.
W. A. ROGERS, Assistant on Construction.
J. E. COYNE, Inspector of Masonry.
C. P. HORTON, " " "
*WM. PARK, " " "

Bids and Contracts. — Bids for the steel-work were opened March 12, 1896, and contract was signed March 17. Bids for construction were opened March 19, 1896; contract was signed March 21.

General Description of Structures. — Two separate single-track subways extend under Boylston street, connecting with the Boylston-street station. The westerly one has the bottom of its masonry about 39 feet below the surface where it leaves the Boylston-street station. Its considerable depth is to allow the cars to pass under the Boylston-street subway in the station. The easterly subway has the bottom of its masonry about 23 feet below the surface where it leaves the station. These two single-track subways converge, and opposite the Hotel Pelham join each other, forming what is conveniently called a "double-barrel" subway. This double-barrel subway continues in Tremont street to a point about 30 feet south of Van Rensselaer place. Near this point the westerly track, which was 13½ feet lower than the easterly track on the northerly side of Boylston street, becomes level with the latter. A cross-section of the double-barrel subway in Boylston street near Hotel Pelham is shown on Plate 25 (Cross-section 5). From near Van Rensselaer place to near the north side of Seaver place is a single so-called wide-arched subway. A cross-section of the wide-arched subway at a point between LaGrange and Eliot streets is shown on Plate 25 (Cross-section 11).

* Part of the time only.

This and other cross-sections show the under-drain for taking care of such water as finds its way into the subway. The normal interior width of the wide-arch subway is 23 feet. The thickness of the brick arch is 2 feet; the thickness of the concrete side-walls near the middle of their height is 3 feet, and is increased to more than double this where it joins the invert. The subway occupies at its foundation a width of over 34 feet. The height of the crown of the arch above the invert is nearly 18 feet. Other dimensions of the various cross-sections can be found on the drawings and from the statistics. Plate 25 (Cross-section 15) is taken just north of Seaver place. This has a greater than normal width on account of its being in the bell-mouth, which joins the wide-arch subway to the double-barrel subway which begins again on the south side of Seaver place. Cross-section 18, Plate 25, shows the double-barrel subway about 17 feet south of Hollis street. At this point the easterly or north-bound track branches, one track being for Tremont street and the other for Shawmut avenue. About 65 feet north of Hollis street the westerly or south-bound track also branches for these two streets. The Shawmut-avenue south-bound track passes under the Tremont-street north-bound track near Common street. Cross-sections 18, 20, 23, and 25, Plate 25, show phases of this crossing. Plate 26 shows a plan of the subway in the vicinity of branches alluded to. All of the subway between Boylston street and Hollis street, whether double-barrel or otherwise, is made mainly of concrete and brick masonry, and has arches with their axes parallel to the axis of the subway. The wide-arch subway is strengthened with $1\frac{3}{4}$-inch tie-rods which are placed 2 feet apart. Every 20 feet on each side of the two-track subway and every 6 feet on each side of the double-barrel subway refuge niches are hollowed out of the side-walls. Each is about 7 feet high, 3 feet wide, and about 15 inches deep. It may be remarked here that the ordinary width of the subway in this vicinity is such as to allow a space of two feet between the outside of the widest street-railway car and the walls between the niches. Plate 27 shows the unfinished junction of the double-barrel and wide-arch subway near Van Rensselaer place. Plate 28 shows the interior of one of the barrels. Both plates show unfinished refuge niches. The double-barrel subway is strengthened by vertical I-beams imbedded in the concrete side-walls, and with tie-rods connecting the tops of every pair of opposite beams. Provision is made for electrically bridging the different members of each steel bent and the different bents with each other by means of tinned copper-wire. As

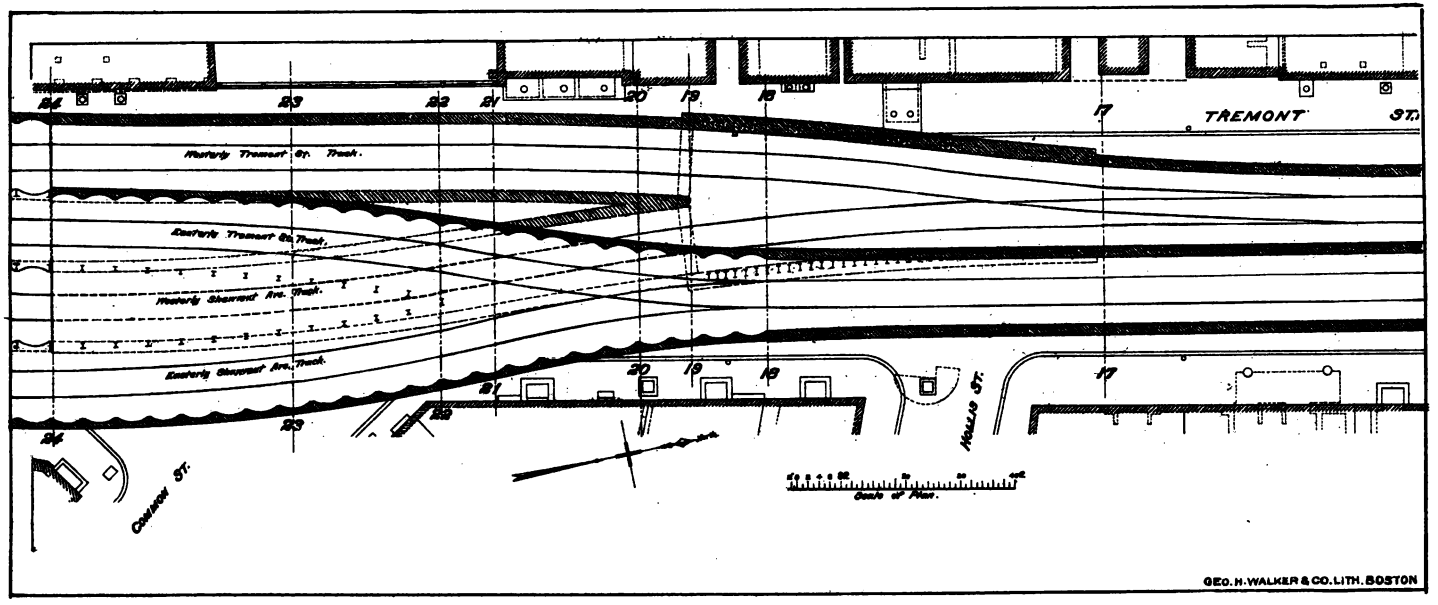


PLATE 26. PLAN OF SUBWAY NEAR COMMON STREET.

PLATE 27. — INTERIOR OF SECTION 4. BELLMOUTH AND DOUBLE-BARREL SUBWAY, NEAR VAN RENSSELAER PLACE, UNDER TREMONT STREET.

PLATE 28. — UNFINISHED INTERIOR OF SECTION 4, UNDER TREMONT STREET. ONE BARREL OF DOUBLE-BARREL SUBWAY. REFUGE NICHES.

fast as different sections of the subway are done, efficient arrangements will be made for the prevention of electrolysis. The upper two tracks south of Cross-section 18 are constructed in a manner similar to that employed in Section 1 of the subway; that is to say, they have roofs made of I-beams with jack arches of brick and concrete masonry, and have side-walls made of steel posts and concrete. South of the southerly side of Common street all of the four tracks have this construction.

The depth to the bottom of the masonry of the subway at different places can be seen by referring to the various cross-sections. Between Boylston street and Seaver place it varies from about 26 to 29 feet; at a point midway between Hollis and Common streets it is about 37 feet below the surface. In general the depth of the subway is such as to allow many of the numerous water and gas pipes to remain undisturbed. Some, however, including a considerable length of the two 30-inch water-mains, were in the way, and had to be relaid in new situations. It was necessary to provide new sewers on each side and connect them with the house-drains. A ventilating chamber for two 7-foot fans and their motors, resembling that on the Common near West street, is located between the Winthrop School and the Hotel Richwood.

On the easterly side of the subway, at Eliot street, a pump-well and chamber is provided similar to the one in the Public Garden. The interior of the bottom of the well is about 10 feet below mean low tide. The chamber is between 11 and 12 feet square inside. It communicates with the surface of the street by means of a manhole placed directly over it, and also by a stairway leading to the sidewalk on the northerly side of Eliot street. Any water that enters the subway between Hamilton place and Pleasant street will be drained into this well: from the north, through a 15-inch pipe, and from the south, through a 12-inch pipe. This structure is illustrated by Plate 29.

The subway and its subsidiary structures have a coating of asphalt passing entirely around them. In some cases they have in addition a coating of cement plaster under the asphalt.

Preliminary Work. — Tunnel. — In order to determine the exact nature of the ground and obtain the benefits of drainage a small tunnel was built direct by the Commission, under the direction of the Engineering Department, before the contract for Section 4 was let. This tunnel was about 3½ feet wide and 5 feet high, and extended from Boylston street to about 20 feet south of Seaver place. It answered several purposes. It was on the line and at the grade of

the intended sub-drain under the invert of the subway. The contractors bidding on the subway were invited to examine it, and it gave them much surer information both as to the character of the most difficult excavation, and as to the amount of water to be encountered, than could be had in any other way. The water draining into this tunnel was kept constantly pumped out, and it served to make the excavation above very much dryer than it would otherwise have been. The ground near Eliot street, for example, which preliminary test pits had shown to be soft and oozy, became firm and easy of excavation. This was not only of direct advantage in the matter of excavation, but was indirectly of still greater advantage in affording safety to buildings. The subway, as will be seen by the cross-sections, goes near to, and much below, some of the buildings. For instance, the excavation was within 7 feet of, and about 18 feet below, the foundation of the Hotel Pelham, which is a seven-story stone building. The information and other benefits afforded by this tunnel enabled prudent contractors to bid and to execute their work far lower than they could otherwise have done. This tunnel was also made use of in temporarily taking care of the drainage from sewers which were cut off.

Underpinning Buildings. — The subway is less than 3 feet from the front of, and about 24 feet below, the foundation of the four-story brick building numbered 285 to 291 Tremont street. A contract was made, prior to the contract for the whole section, for underpinning a portion of this building to the depth of the invert of the subway. For similar reasons, a preliminary contract was made for underpinning the three-story brick building numbered 284 to 294 Tremont street to a depth of 15 feet below the foundation. The contract for Section 4 provides that if any other buildings need underpinning it shall be done by the contractor for the section, and he is responsible for any injury to these buildings caused by his act or neglect. Careful levels are frequently taken on all the buildings on the side of this contract section. Up to the date of this report (August 15, 1896) no settlements of any of them have been discovered.

Method of doing the Work. — In order to demonstrate that the work could be done by the slice method, heretofore described, without extraordinary expense, the Commission had two slices each about 12 feet in length of the two-track subway built by day labor under the direction of its engineers before the contract was let.

PLATE 30. — VIEW ON TREMONT STREET, DURING CONSTRUCTION OF SECTION 4. BRIDGES CAN BE SEEN BEYOND CROSS-WALK. May 8, 1896.

PLATE 31. — SECTION 4, EXCAVATING-MACHINE ON TREMONT STREET. BRIDGES OVER SLICES. July 17, 1896.

PLATE 32. — INCLINES AT JUNCTION OF SHAWMUT AVENUE AND TREMONT STREET.
BRIDGE OVER SLICE. July 17, 1896.

The work has been prosecuted day and night. In the daytime the contractor has at one or more points occupied about one-third of the width of the street between the curbs. The remainder of the width of the street has been open to all kinds of traffic, including full service of both lines of the street-car track. Plate 30 illustrates the appearance of the street in the daytime while the subway work was in progress. This photograph also shows bridges over slices of excavation, but the bridges being even with the paving and of nearly the same color are distinguished with difficulty. Probably few of the passengers of the street cars were aware that subway work was going on underneath them. After seven o'clock at night only one line of track was kept in service, and the contractor was allowed to occupy about two-thirds of the width of the street. After half-past eleven at night the electric-car traffic was turned into other streets, but the contractor was compelled to so arrange that fire-engines could pass lengthwise through the streets and into or out of any adjacent street.

Machinery used. — Two kinds of hoisting-machines have been employed, — the so-called incline, and a special form of trench machine lifting one or two tubs at a time, as the conditions of the work permitted. In the daytime these are worked generally on the easterly side of the street; at night they are quickly moved, when required, to the middle or westerly side of the street. Plates 31 and 32 illustrate these machines.

Work done. — Since March 30, or when excavation on Section 4 was begun, up to this date (August 15), 61 slices, having an aggregate length of 732 feet, measured lengthwise of the subway, have been opened. The masonry is practically completed in 235 feet of the double-barrel subway between Boylston street and Van Rensselaer place, and in 30 feet of double-barrel subway south of Seaver place. Three hundred and fifty-seven feet of wide-arch subway is complete, with the exception of the roof of one slice. One slice of steel-work near Warrenton street is also complete.

SECTION 5.

Location. — In and near the so-called triangle bounded by Warrenton, Tremont, and Pleasant streets and Shawmut avenue.

Contractor for Removing Buildings. — A. A. ELSTON & Co., 166 Devonshire street, Boston, Mass.

Contractors for Steel Work. — BOSTON BRIDGE WORKS, 70 Kilby street, Boston.

Contractor for Construction. — The bids for this will be opened August 27.

Removing Buildings on Triangle. — The contract was signed March 31, 1896; work was done May 15, 1896. Six brick buildings from two to five stories high, and nine frame buildings from one to three stories high, were removed above foundations.

Structures. — This section includes a short distance of four-track subway adjoining the four-track subway at Section 4, and an incline by which these four tracks reach the surface at Pleasant street. The construction will be such as to permit a building (say, an apartment-house) of eleven stories in height, of fireproof construction, to be built over the nearly triangular space included between Shawmut avenue and Tremont street and between Warrenton street and Pleasant street. It is proposed to place a platform between the two interior tracks and outside of the two exterior tracks, so that this locality can be used as a station. The platforms will have inclinations of about 5 per cent. A plan of this station is given on Plate 35.

WORK DONE ON SECTION 6 OF THE SUBWAY FOR THE YEAR ENDING AUGUST 15, 1896.

Location. — In Tremont street, from Park street to a point about 64 feet south of Court street.

Contractors for Steel Work. — THE BERLIN IRON BRIDGE COMPANY, East Berlin, Conn.

Contractors for Construction. — R. A. MALONE & CO., Boston, Mass. M. TALLENT, a member of the firm, has acted as superintendent for the Contractor.

City Assistants.

HENRY H. MARDEN, JR., Assistant Engineer.
E. ELBERT YOUNG, Assistant Engineer.
JOHN J. FALVEY, Transitman.
CHARLES H. JOHNSON, Transitman.
CHARLES A. WENTWORTH, Assistant Transitman.
LEONARDO FURLONG, Rodman.
*ALFRED K. DOWNS, Rodman.
*FRANCIS H. WATTS, Rodman.
CHARLES H. SMITH, Assistant on Construction.
JOSEPH DRISCOLL, Assistant on Construction.
*HUGH BORLAND, Assistant on Construction.
B. RUDOLPH DORMAN, Inspector.

M. Tallent was foreman of experimental work, for the Commission, previous to the commencement of contract work.

Bids and Contracts. — Bids for the steel-work were opened April 30, 1896, and contract was signed May 4. Bids for construction were opened May 7, 1896; contract was signed May 9.

* Part of the time only.

PLATE 33. — BUILDINGS TO BE REMOVED ON EASTERLY SIDE OF TREMONT STREET, FROM PLEASANT STREET TO SHAWMUT AVENUE. July 20, 1895.

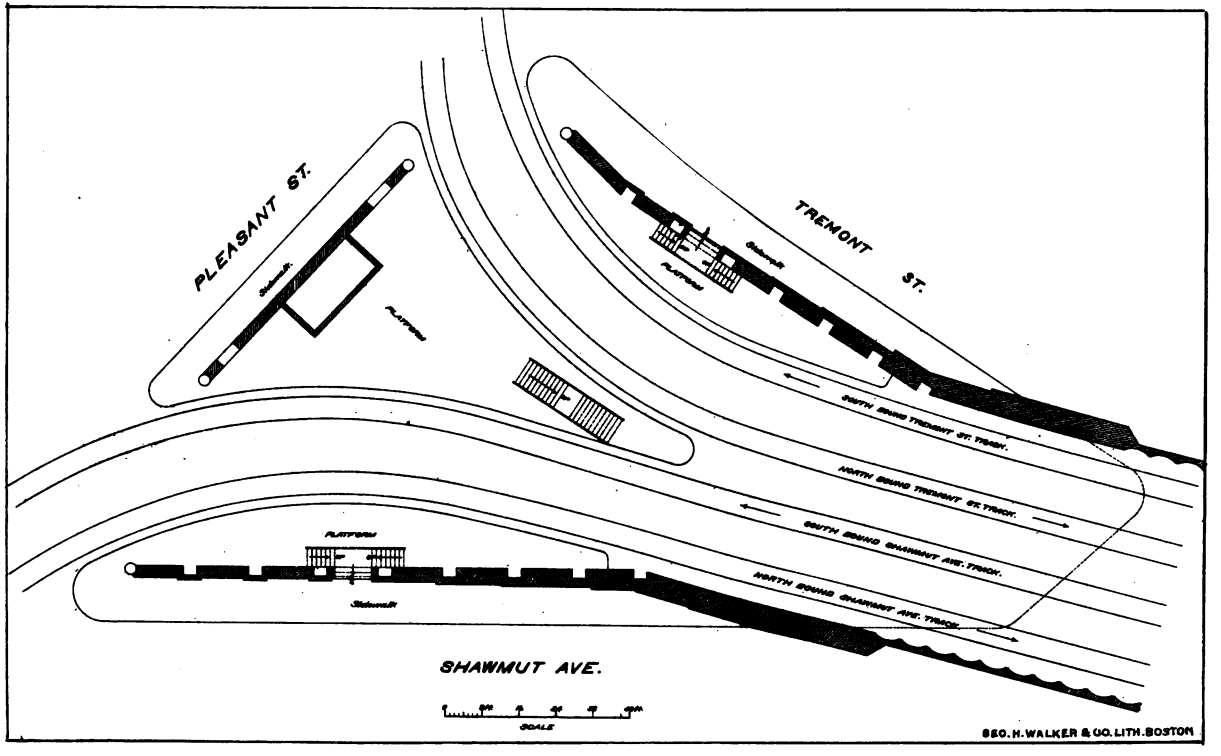


PLATE 35. PLAN OF STATION, CORNER OF SHAWMUT AVENUE AND TREMONT STREET.

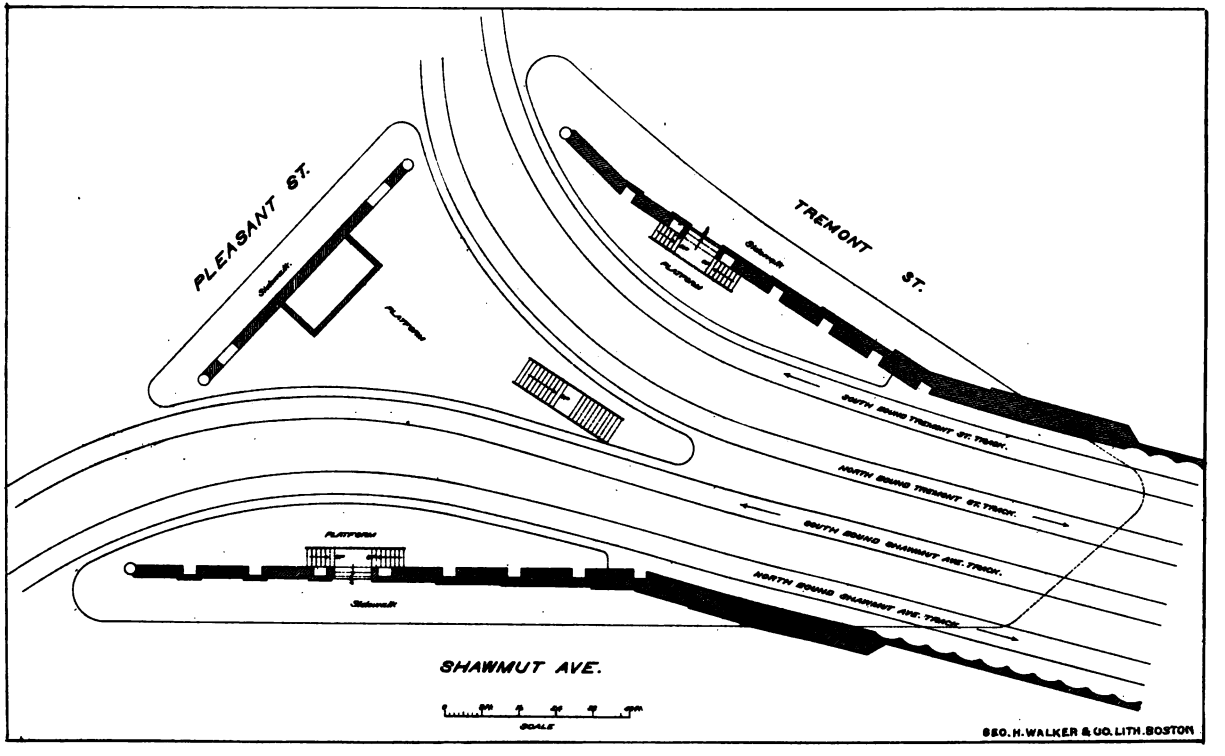


PLATE 35. PLAN OF STATION, CORNER OF SHAWMUT AVENUE AND TREMONT STREET.

strengthened by tie-rods and has niches 10 feet apart. The side-walls are built of concrete, and are 3 feet thick at their middle height and much wider at the base. It is intended in most places to have the arch entirely stable with any conditions of loading, even if the earth should be entirely removed from the sides to the bottom of the foundation. In various places, however, where it was deemed improbable that excavations for building, or otherwise, would extend as far as the bottom of the foundation, the spreading out or so-called toe of the side-wall is omitted. Section 6 has a total length of 1,085 feet. The depth of the top of the masonry below the surface of the street at the northerly end of the bell-mouth is 9½ feet, at the bottom of the masonry about 31 feet. Corresponding distances at Bosworth street are, respectively, 13½ and 34¾ feet; opposite the middle of the Tremont building, 12½ and 34 feet; at School street, 11¼ and 32¾ feet; opposite the middle of the Museum building, about 6¾ and 28¼ feet. For most of the distance the tracks on Section 6 will have a grade, descending towards the north, of one-third of one per cent. Cross-sections of this subway at various points between the Park-street church and Scollay square are shown on Plate 36. These cross-sections show the front walls of the buildings and foundations, the area walls, the sidewalk, and various objects under the street surface. An interesting cross-section on Plate 37, showing a cross-section of the subway and of the front walls of the Parker House and Tremont building, indicates the value of land in this vicinity.

A ventilating chamber for two 7-foot fans (Plate 38) is to be built just north of King's Chapel. The position selected for the shaft will probably be in the burial-ground just north of King's Chapel.

Preliminary Work. — During the time of advertising for bids, work was begun by the Commission to determine to a greater extent than that shown by the borings the character of the softest ground. A "slice" (called later Slice No. 3) was begun April 11, 1896, opposite the Massachusetts Historical building on Tremont street. From this slice small headings on each side were driven in positions to be occupied by the bottoms of the side-walls. Contractors were invited to visit these drifts. The work was continued until the contract was awarded May 7, 1896. The material gained in excavation was carried by a trench-machine across the King's Chapel burying-ground to Court square, where it was dumped into a hopper. From the latter it was taken into carts and used as a part of the grading in Boston Common.

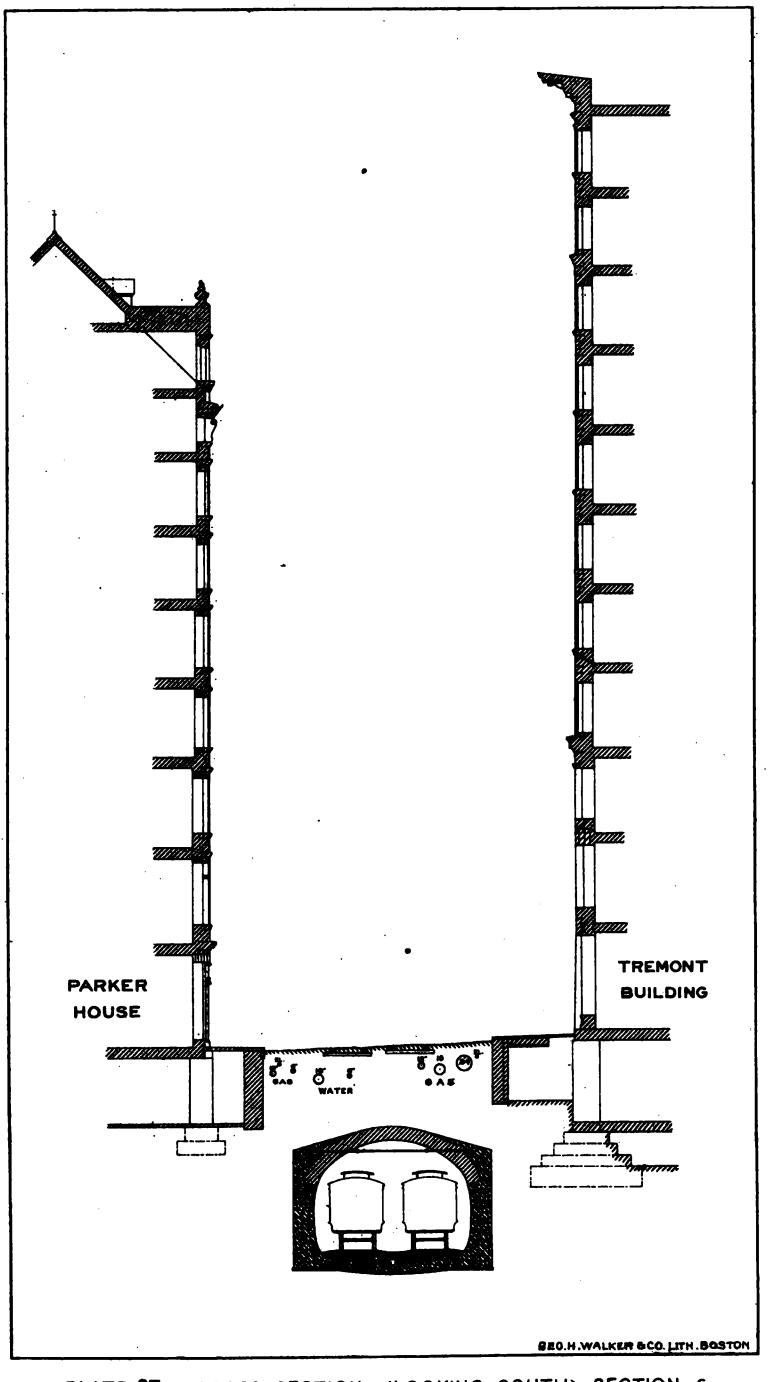


PLATE 87. CROSS SECTION, (LOOKING SOUTH) SECTION 6, NEAR SCHOOL STREET.

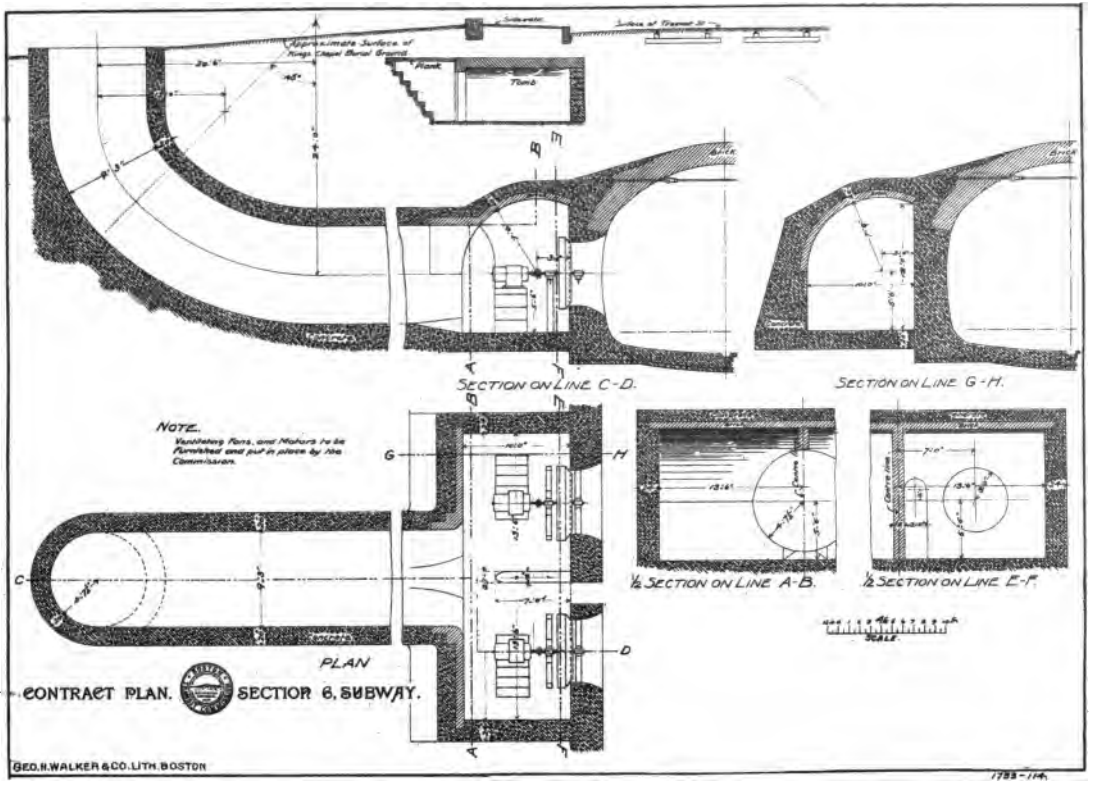


PLATE 38. VENTILATING CHAMBER, SECTION 6.

from King's Chapel burying-ground to Court street along the east side of Tremont street over the sidewalk. At the request of the contractor the contract was modified so as to allow 48 feet to be built at the northerly end by the slice method, instead of 24 feet. Excavation for two separate slices, 24 feet apart, near the northerly end of the contract, were begun May 14 and 15, the northerly one being called Slice No. 1, and the southerly one, Slice No. 2.

After these were excavated to grade the contractor was allowed to connect them by tunnelling as a demonstration of the method which he desired to follow in prosecuting the work. The method for tunnelling the side-walls was to drive on each side a small heading about half the height of the side-wall, build in this the concrete as far as its height would allow, then drive a second heading immediately over the first to get the full height. Midway between the side-walls a centre drift about 10 feet wide and 6 feet high was driven with its top somewhat above the proposed top of the arch. In this were placed crown bars consisting of piles 12 feet to 14 feet long. The central drift was widened out by driving lagging from these bars at right angles to the direction of the centre drift. The bars, roof, earth, and traffic above it rested on posts. Footings were placed under the posts, but not so large as advised by the engineer. While these operations were going on, a central drift had been run between the slice excavated by the Commission at the Historical Society and the more southerly of the two slices excavated by the contractor. Two other short sections of tunnel by the crown bar system were started a little later than the one mentioned above. In all these localities slight settlements of the street began after putting in the central drifts, and these settlements continued to increase after the drifts were widened out.

The settlements on the street were sufficient to make it look somewhat unsightly, but not enough to prevent running of cars. Excavating the drifts for the side-walls and other operations had caused the area-walls under the curbstone to settle slightly and to show slight cracks where they joined the side-walls of the buildings.

Before the contractor had begun the demonstration of the method of tunnelling he wished to employ, he was informed that the system would probably not be satisfactory, as it usually, if not always, occasioned settlements in soft ground. On July 7 the contractors were notified that the crown bar system of tunnelling was not satisfactory, and that some other method must be employed. July 29 permission was given to the contractors to finish all the work north of Beacon

PLATE 39. — SECTION 6, TREMONT STREET, NEAR KING'S CHAPEL.

PLATE 40. — SECTION 6, TREMONT STREET, LOOKING TOWARDS SCOLLAY SQUARE. VIEW SHOWING SPACE OCCUPIED BY SHAFTS AND CONVEYOR. May 25, 1896.

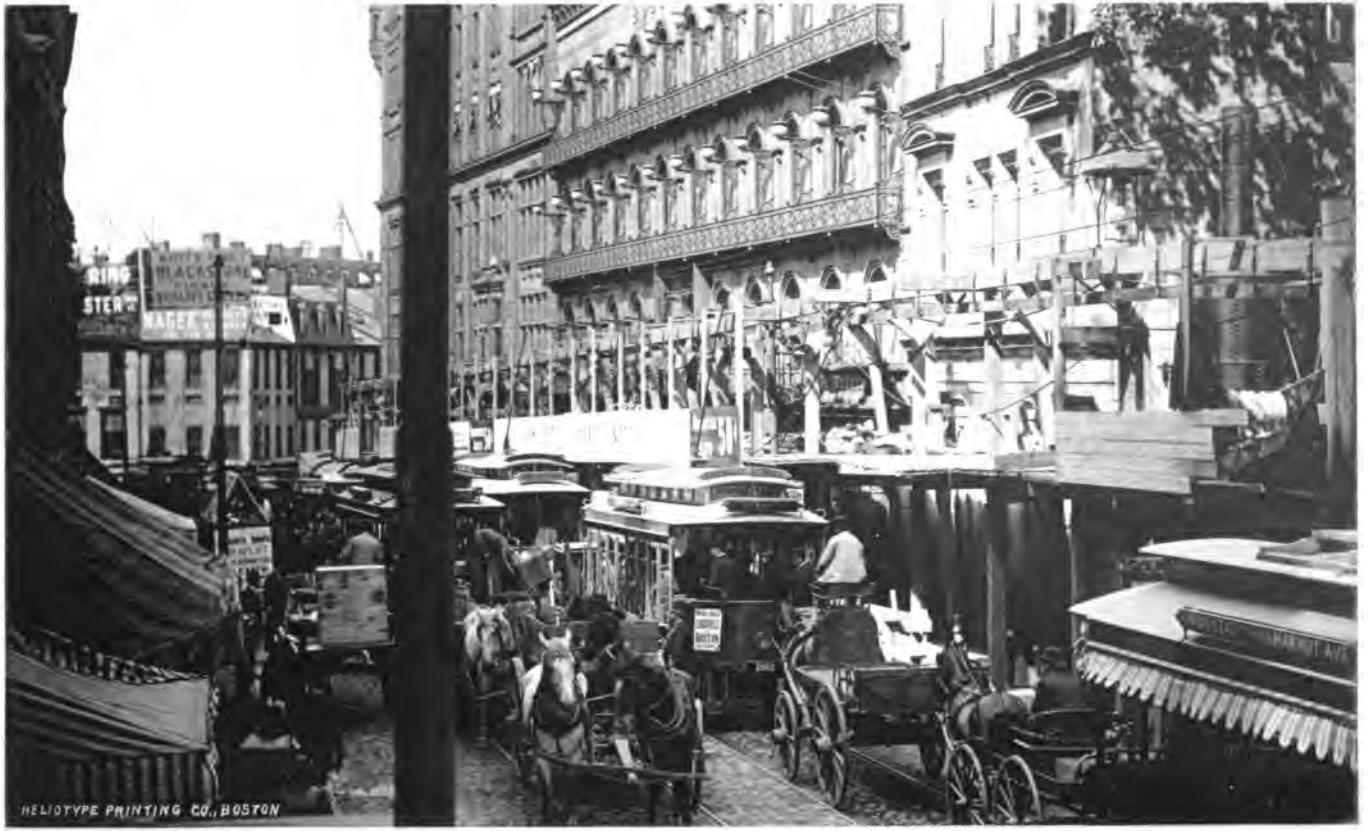


PLATE 41. — TRAVEL ON TREMONT STREET, OPPOSITE BOSTON MUSEUM. June 2, 1896.

PLATE 42. — SECTION 6, CONVEYOR ON TREMONT STREET, NEAR PARK-STREET CHURCH.

street by the slice method. Preparations were immediately made by the contractor to follow out this policy, and additional slices were started opposite the Museum. The conveyor along Tremont street was extended to cover all the work from Beacon street to Scollay square. Work on the slices, however, did not proceed satisfactorily, and the engineers and inspectors were compelled frequently to point out to the contractors the unsatisfactory manner of timbering the work. A small cave occurred on the night of August 10 in the slice at Station 10 (in front of the Boston Museum) during the bracing of a slice which was in process of excavation. A leak occurred in the old 12-inch water-pipe at this point at about the same time. Probably the leak occurred prior to the cave, and, in connection with the poor bracing, was the cause of it. About four or five cubic yards of earth came into the subway on this occasion. The heavy beams which supported the track and surface of the street did not yield. Immediately after the cave occurred the street cars were, as a matter of prudence, turned into another street, although it is not probable that any accident would have occurred if the cars had continued to run as before. In accordance with the contract, the cars on the south-bound track are shut off at 7 o'clock each evening, and on the north-bound track at 11.30. The street-car traffic was thus stopped about three-quarters of an hour sooner than would have been the case otherwise. Between 9 and 10 o'clock the next morning it was deemed advisable to shut off the north-bound track again for two hours in order to repair the water-pipe, and thoroughly examine under the bridge. The accident above detailed was unfortunate, not only on account of some interference with street traffic, but much more on account of the exaggerated rumors that were started in consequence. On August 13 the Chief Engineer certified to the Commission as to the operations of the contractor on Section 6. On the same date the Commission arranged that the contractor should cease all work within one week, and directed the Chief Engineer to proceed thereafter to construct Section 6 by men employed directly by the Commission.

Accidents. — No serious accidents have occurred, but there were several minor ones, such as are common in this class of work.

Plant. — The plant used by the contractors consists of conveyors built on the general principles of trench machines. One of these extends over the sidewalk as far as Scollay square, where a hopper is located, into which earth from the tubs is dumped, and where teams are loaded. A second

conveyor extends from the corner of School street and Tremont street along Tremont street to King's Chapel, and thence to a second hopper in Court square.

The third conveyor is on the west side of Tremont street, from the southerly end of the Tremont Building to Park street. For working nights, the contractor provides, in addition, an A-frame mounted on a truck, which is hauled in front of the middle of the Tremont Building, and used there from 7 at night until 6 in the morning, for excavation from a shaft at this point.

Lighting underground work is done mainly by means of incandescent lights. But little pumping has been necessary. Water that has accumulated from storms, street-washing, and leaking has been, in the main, removed by means of hoisting-tubs and by other similar contrivances.

SECTION 10.

Location. — In Haymarket square and Washington street to the northerly line of Hanover street.

Contractors for Steel Columns for Subway Side-walls. — THE PENNSYLVANIA STEEL COMPANY, Steelton, Pa.

Contract dated July 28, 1896.

Contractors for Steel Work for Station and for Roof of Subway. — THE CARNEGIE STEEL COMPANY, LIMITED, Pittsburgh, Pa.

Contract dated August 11, 1896.

Assistants.

JOHN E. PALMER, Assistant Engineer.
ROBERT B. FARWELL, Transitman.
GEORGE W. JEPSON, Rodman.
FRANCIS P. GARLAND, Rodman.
A. E. WEAVING, Principal Night Foreman.
CHARLES R. GOW, Assistant on Construction.

This section includes a four-track subway in Washington street north of Hanover street, which, at Haymarket square, widens out and becomes the Haymarket-square station. Plate 43 shows a cross-section of the four-track subway about 210 feet north of Hanover street. It will have a total width inside of about 47 feet. At the point where this cross-section is taken the back side of the subway wall comes within about 2½ feet of the foundation-walls of the building and is carried to a point about 9 feet below. At other points the back wall comes closer to the buildings and extends to a greater depth; for instance, on the westerly side of the subway near Hanover street the back of the subway wall is within a foot of the foundation-wall of the

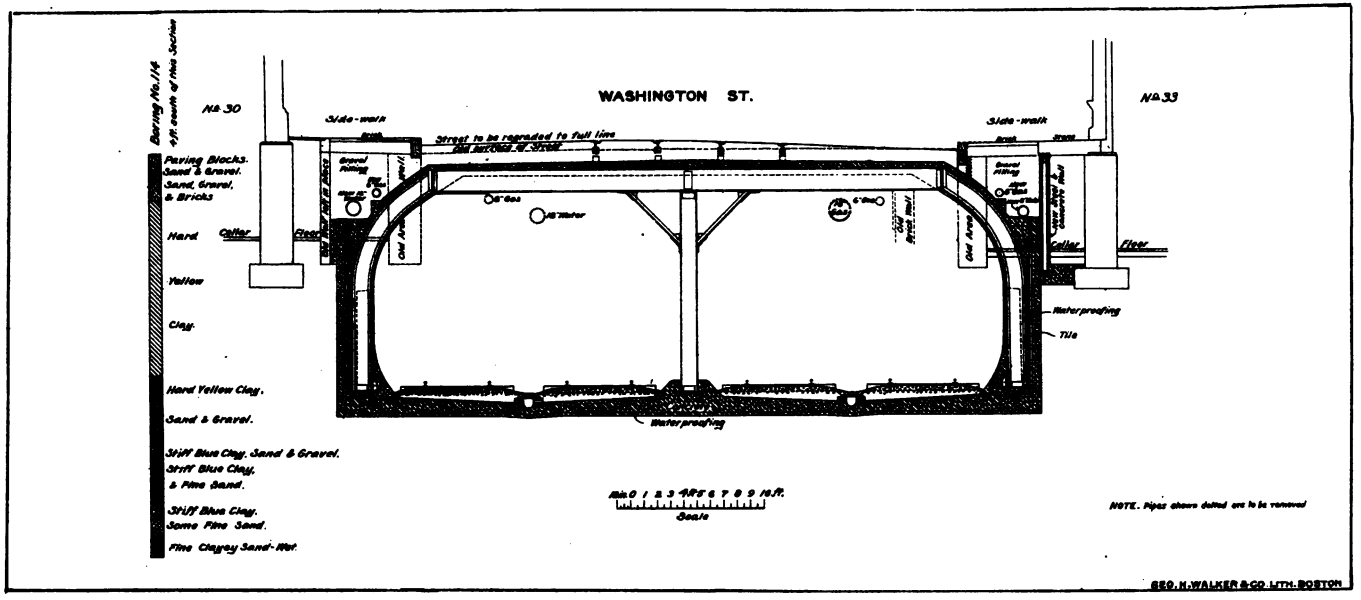


PLATE 43. CROSS SECTION (LOOKING SOUTH) OF FOUR TRACK SUBWAY, SECTION 10, 210 FT. NORTH OF HANOVER STREET.

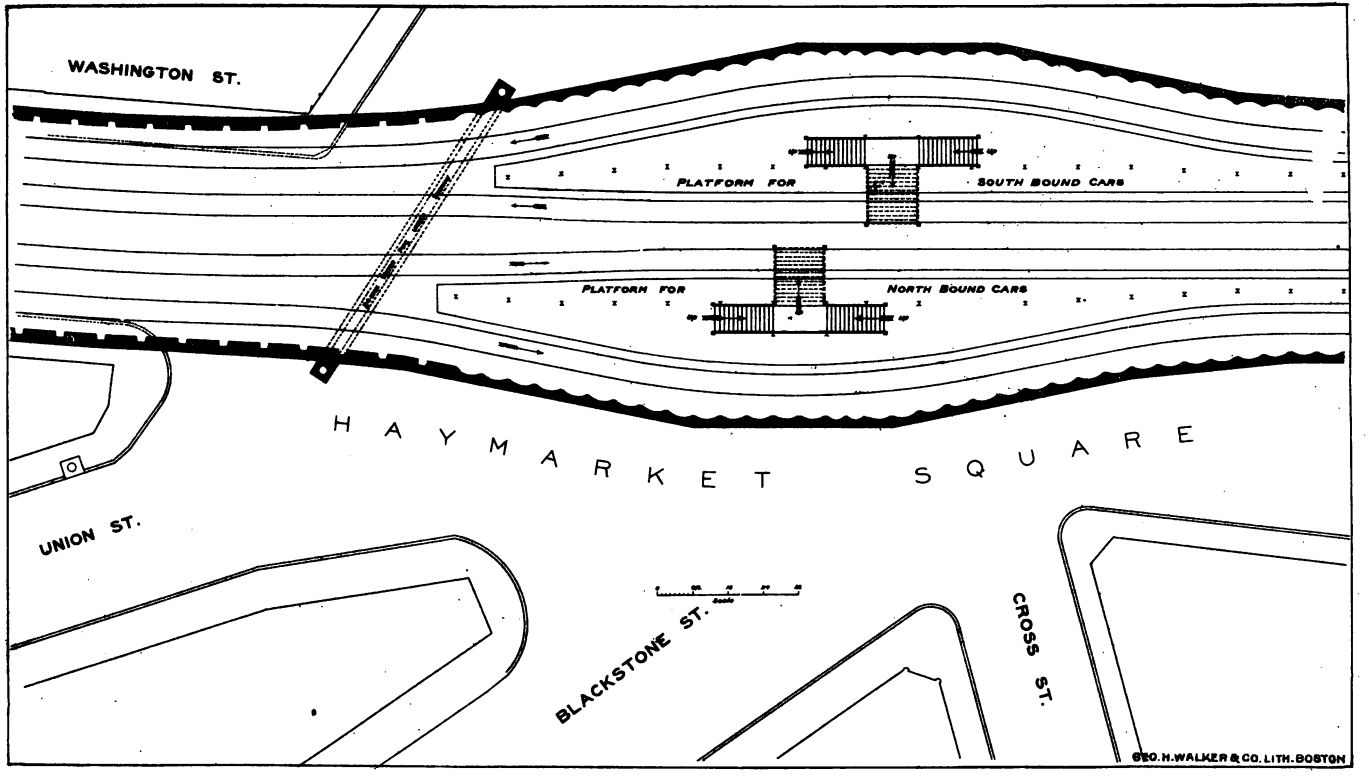


PLATE 44. PLAN OF HAYMARKET SQUARE STATION.

PLATE 45. — SECTION 10, BUILDING SIDEWALLS OF SUBWAY IN WASHINGTON STREET.

building and extends to a depth of about 10½ feet below this wall. As the subway comes too close to the surface of the street to admit of laying pipes and sewers in the roadway, these will be laid under the sidewalks; and to provide room for these the upper corners of the cross-section of the subway are rounded as shown on the drawing. The wall of the subway is of concrete, 32 inches thick, in which are imbedded, every 3 feet, curved steel posts. In the interior of the walls, about 8 inches from the back nearest the building, is a series of hollow spaces formed by ribbed tiles. The back of the wall is covered with asphalt.

Any water which penetrates the asphalt and 8 inches of concrete will enter this hollow space formed by the ribbed tiling and be freely carried to the subway pumps. This is for the purpose of causing the interior portion of the subway walls to be relatively dry.

The roof of the subway and both the side-walls and roof of the station will be composed of the combination of steel and brick and concrete masonry well known from its use in Sections 1, 2, and 3 and in some other parts of the subway. The steel roof-beams in the subway are attached to the curved posts already alluded to. A plan of the station is shown on Plate 44. It will have two island platforms, the easterly for north-bound cars, the westerly one for south-bound cars. These platforms are about 19 feet wide in the middle, tapering to about 7.5 feet at the ends. Each has a length of about 164 feet. Each platform will have a stairway near its centre, and a single building on the surface will suffice to cover the two stairways.

In building the side-walls of the four-track subway which come so close to the buildings and extend so far below their foundations, it is necessary to use skill and very great care. It is also desirable to obstruct the sidewalks and interfere with the business of the tenants of adjoining buildings as little as possible. For these reasons the side-walls of the four-track subway on Section 10 are being done by the Commission itself under the direction of its engineers. Excavating for these side-walls began July 22, 1896. Work is being done night and day, and it is considered a matter of necessity to do much of this work on Sunday. So far no settlements of buildings have taken place that can be detected by careful levelling.

The excavation for these side-walls is being done in alternate pockets, each some 12 to 15 feet long and about 9 feet wide. These pockets are separated by intervals of about 12 feet, and the intervening pocket is not excavated until the walls of the first are thoroughly secured.

The work of building the Haymarket-square station and that portion of the four-track subway lying between the side-walls already mentioned will be done by contract, for which bids will be opened September 8, 1896.

REPORT OF OPERATIONS ON BOSTON COMMON DURING YEAR ENDING AUGUST 15, 1896.

Engineers employed on this Work.

E. E. YOUNG, Assistant Engineer, to May 12, 1896.
JOHN E. PALMER, Assistant Engineer, May 12 to August 15, 1896.
ROBERT B. FARWELL, Transitman.
GEO. W. JEPSON, Rodman.

It was decided last year to dispose of as much as possible of the earth excavated in the Boylston and Tremont street malls (contract Sections 1, 2, and 3) upon other parts of the Public Garden and Common. Some of the reasons for such disposition were: to save the cost of transporting the material to more distant points; to avoid to that extent encumbering the streets with dirt-carts; and also to raise the grades where the grounds were wet and muddy. The work of filling was begun in June, 1895, and has been continued to the present date, 67,000 cubic yards of surplus earth having been disposed of in this way. Certain trees which were likely to be injured by this filling have been raised. Of fourty-four so treated, six have died and the others appear to be thriving. Four other trees in the Public Garden have died.

REPORT ON CHANGES IN PIPES AND SEWERS FOR YEAR ENDING AUGUST 15, 1896.

Considerations of economy in construction and of reducing to a minimum the liability to injury to the foundations of adjacent buildings have led to the establishment of grades which bring much of the subway roof close to the surface of the street. Such portions of the streets, therefore, as are usually occupied by sewers, water and gas pipes, and electric conduits have been taken by the subway, and the best disposition practicable has been made for the obstructing pipes. Where the pipes have been comparatively few and small they have been given new locations on either side of the street. In some cases where the subway walls come very near to the building lines, as in parts of Washington street, the subway has been shaped with rounded corners to provide proper places for the pipes. In some cases where the pipes are many and large, as in Tremont street from Boylston street

PLATE 46. — PIPE CHANGES IN DOCK SQUARE.

to Seaver place, the pipes, except sewers, have mainly been allowed to remain as found, and the subway has been placed at a lower depth. From Seaver place to Warrenton street in Tremont street the avoidance of a grade crossing of subway tracks and the nearness to the Pleasant-street incline required the moving of nearly every pipe in the street. The westerly track at this point is a sub-subway. Over its roof and through a space about 8 feet in depth and 14 feet in width at the narrowest part, two 30-inch water-pipes, a 12-inch water-pipe, a 24-inch, a 12-inch, an 8-inch, and a 6-inch gas-pipe, and two electric conduits, one containing 12 ducts, are carried. See Plate 25, Cross-sections 20, 23, and 25.

In making the changes great care has been taken to make as little hindrance to street traffic and as little inconvenience to the public as practicable. The work has been done largely at night and on Sundays, and much of the earth has been removed from the street and brought back when the trenches were ready for refilling. In Tremont street between Boylston and Park and at some street crossings the work has been done in tunnels, notwithstanding the great increase in cost. At street intersections the pipes are especially crowded, and street-railway tracks occupy a large part of the street. The cost of labor per hour is greater on account of night and Sunday work, and the work of changing pipes under such conditions costs from three to four times as much as in an ordinary street. Plate No. 46, from a photograph taken in Dock square, shows some of the obstructions met with in laying new pipes across a street, even without the complication of car tracks.

Changes in sewers, after approval of the plans by the Superintendent of Streets, have been made by the Commission; the work of making them being included in the contracts for the construction of the various sections, or let by separate contracts, or done by the day, as was deemed most expedient.

The changes in water-pipes, after approval by the Water Department of the city of Boston, have been made by day work, except the special constructions needed in the design of the subway. These have been included in the regular subway contracts.

In accordance with law, orders have been issued to the various gas, electric-light, and telephone companies whose pipes or conduits have interfered with the construction of the subway, for the removal of such pipes or conduits, and new locations for them have been granted. Upon the refusal by the Bay State Gas and the Boston Gas Light

Companies to comply with the orders within the times specified, the work of removing their pipes, and of laying new pipes in place of those removed, has been done by the Commission, partly by day work and partly by contract.

The Brookline Gas Light Company, the Boston Electric Light Company, the Edison Electric Illuminating Company, and the New England Telephone and Telegraph Company have so far made, as directed, the necessary changes without expense to the Commission.

The different changes are enumerated in detail below:

Sewers. — To replace a 16-inch sewer and its connections, which drained the north-eastern part of the Common and was cut by Section 3 at West street, a new sewer was built, under contract with Charles Linehan, in the Common from West street to Charles street. In this sewer and its connections there were laid the following lengths of pipe: 18-inch, 353 linear feet; 15-inch, 408 linear feet; 12-inch, 527 linear feet; 8-inch, 624 linear feet. Eight manholes and five catch-basins were also built as a part of it, and an old manhole extended up to grade. This work was in charge of Assistant Engineer E. E. Young.

At the junction of Tremont and Park streets the 20-inch brick sewers were replaced by 20-inch and 15-inch pipe sewers, special constructions being introduced in the roof of the two branches of the subway at that point to allow of a suitable grade for the new 15-inch pipe sewer in Park street. The changes in these sewers were made under the contract with E. W. Everson for building Section 3½ of the subway, and consisted of the following: 20-inch pipe, 105.61 linear feet; 15-inch pipe, 247 linear feet; 12-inch pipe, 1.57 linear feet; 10-inch pipe, 16.25 linear feet; 3 manholes, 3 catch-basins, and 1 drop inlet.

For Section 4 it has been necessary to remove entirely the old sewers in Tremont street between Boylston and Warrenton streets, to lay a new sewer on either side of the subway, to change the direction of the flow of the sewage to the west in Eliot street between Tremont and Warrenton streets, and to divert the sewage in the Warrenton-street sewer east of Tremont street through Shawmut avenue to Pleasant street. The sewers in Tremont street parallel to the subway are 10-inch and 12-inch pipes laid close to the subway wall, and in the same trench with it, and are included in the contract for building Section 4.

The Eliot-street sewer was a 20-inch pipe, and was laid from Tremont street to Carver street by day work, under the charge of Assistant Engineer F. B. Edwards. In it there were 525 linear feet 20-inch pipe, 6 linear feet 15-inch pipe, and 3 manholes. The new Shawmut-avenue sewer was built by the day and contained 125.5 linear feet 10-inch pipe, 238.5 linear feet 12-inch pipe, and 2 manholes. Work was begun on it May 24, 1896, and finished June 3, 1896. The cost, including the manholes and connections with old sewers, was $3.54 per linear foot; average depth of trench 10 feet.

Water-pipes. — For the different sections there have been removed and laid during the year the following linear feet of pipe:

		Size.	Linear feet removed.	Linear feet laid.
SECTION	1.	20-inch	74	90
		16-inch	119.5	138
"	2.	40-inch	310	380
		30-inch	431.5	510.6
		30-inch, temporary		50
		Gates set, one 36-inch and one 30-inch.		
"	3½.	6-inch, temporary	26	31
"	4.	30-inch	1,467	1,454.3
		16-inch	9.5	41.5
		12-inch	82.5	235.3
		8-inch	230.5	115
		6-inch	54	9
		Gates set, two 30-inch and one 12-inch.		
		Gates removed, one 12-inch.		
"	8.	4-inch	9	9
		6-inch	490	
		8-inch		490
		Gates set, three 8-inch.		
		Gates removed, two 6-inch.		
		Two hydrants reset.		
"	10.	24-inch	28	28
		20-inch	189.7	97.6
		12-inch		35.5
		8-inch		49.3
		6-inch	136	17
		4-inch	22	
		Gates set, one 24-inch, one 20-inch, one 12-inch, one 8-inch, two 6-inch.		
		Gates removed, two 20-inch, two 6-inch, and one 4-inch.		
		Total	3,679.2	3,781.1

The 20-inch and 16-inch pipes crossing Section 1 at Park square were carried across the roof of the subway in bays of special construction.

The 30-inch and 40-inch pipes which were in the way of Section 2 were carried beneath the subway in a masonry conduit, accessible for any necessary work on the pipes, and designed to admit of no possibility of the flooding of the subway in case of a break in the pipes, and to withstand a bursting pressure equal to that which would result if the conduit and its manhole were filled with water to the level of the street surface above it. For the further protection of the subway a new gate was placed on each of the 30-inch and 40-inch pipe lines in Tremont street near the conduit. Steel and concrete anchorages were built to resist a water pressure of 100 pounds to the square inch at the upper bends in the pipes. The conduit was built as a part of Section 2. Such parts of the 30-inch and 40-inch lines, except the connections with the old pipes, as had to be laid under Tremont street between Boylston street and the easterly end of the conduit, were laid, in order not to impede street traffic, in tunnels driven as close to the surface of the street as was practicable. The dimensions of the tunnels were such as to give from 15 to 18 inches clear between the pipe and side lagging and 2 feet clear between the pipe and bottom of tunnel caps.

Between Eliot street and Boylston street, in Tremont street, where a change in the location of a 30-inch pipe was required, of, on an average,

about three feet, a length of 307.5 linear feet of the old pipe was cut off and moved bodily by lifting-screws and rollers into the position required. The cost of moving the pipe was $5.66 per linear foot. A heavy rain-storm interfered with the work, requiring the removal from the street of nearly all earth taken out of the trench and its return for refilling, and increased inordinately the cost of the work. In crossing Boylston street at Tremont street, to provide a passage for the 30-inch water-pipe, it was first necessary to relocate a 6-inch and an 8-inch gas-pipe, an 8-inch and a 12-inch water-pipe, and to break through and fill with earth a fire reservoir.

Between Seaver place and Warrenton street, both 30-inch water-mains in Tremont street were changed. They were laid in the same trench at a distance of 2 feet clear between them. In a part of the same trench was also laid a temporary 6-inch pipe sewer to drain the houses whose former connections with the main sewer in the street were cut off by the new position of the water-pipes. A new gate was placed on each 30-inch line south of Warrenton street just outside the subway limits, to provide more surely against any damage to the subway from the proximity to it of these pipes in Tremont street.

In order to avoid laying two water-pipes in Cornhill, one on each side of the subway, the services on the northerly side of Cornhill will be transferred to the Brattle-street pipe. The former 6-inch pipe in Brattle street has therefore been replaced by an 8-inch pipe, to accommodate the additional number of services put upon it.

The cost per linear foot of laying water-pipes, including labor, pipe, refilling, and paving, has been as given in the following table:

Size.	Paving on gravel.	In tunnel.	At busy street-crossings.
8-inch	$1 64		$5 18
12-inch			5 08
16-inch	3 72		
20-inch	4 98		
30-inch		$14 51	11 46
40-inch		21 68	
Two 30-inch in same trench	21 65 *		

GAS-PIPES.

Bay State Gas and Boston Gas Light Companies' Pipes.

	Size.	Linear feet removed.	Linear feet laid.
SECTION 1.	4-inch	56	10
	6-inch		66
	12-inch	77.5	91
	20-inch	48	88
	Gates removed, one 4-inch, two 12-inch.		
	Gates set, one 4-inch, two 12-inch.		
Carried forward,		133.5	167

* Including cost of 195 linear feet 6-inch temporary pipe-sewer in same trench and cost of changing house connections.

	Size.	Linear feet removed.	Linear feet laid.
Brought forward,		133.5	167
SECTION 2.	6-inch	11	11
	8-inch	27	27
	12-inch	66	66
	24-inch	94	100
	Gates removed, one old-fashioned valve box, 12-inch.		
	Gates set, one 8-inch.		
" 3.	4-inch	17	17
	10-inch	13	15
	12-inch	173	199.8
	18-inch	144.5	149.3
	20-inch	36.5	11
	24-inch	375	407
	Gates removed, two 12-inch, one 20-inch, one 24-inch.		
	Gates set, two 12-inch, one 18-inch, one 20-inch, two 24-inch.		
" 4.	3-inch		39.7
	4-inch		226
	6-inch	240	164.5
	8-inch	148	24
	12-inch	427	447
	20-inch	26	22.5
	24-inch	329	367
	Gates removed, one 12-inch, one 6-inch, one 8-inch, two 20-inch.		
	Gates set, one 24-inch, two 20-inch, one 12-inch, one 6-inch, two 4-inch.		
	Brookline Gas Light Co.'s Pipes.		
	6-inch	87	109
	8-inch	187	231.
	Gate removed, one 6-inch.		
	Gate set, one 6-inch.		
	Bay State Gas and Boston Gas Light Companies' Pipes.		
SECTION 8.	12-inch	712	982
	Gate removed, one 12-inch.		
	Gate set, one 12-inch.		
SECTIONS 9 & 10.	18-in.	8	972.5
	6-in.	26.4	26.4
	Gate set, one 18-inch.		
	Total	3,328.9	4,870.2

The changes in the 24-in. and 12-in. pipes in Tremont street between Temple place and Park street for Section 3 were made for as long a distance as was practicable in a tunnel, so as to interfere as little as possible with the normal use of the streets. For a part of the distance a 24-in. and a 12-in. pipe were laid in the tunnel together, and for the rest a 24-in. pipe alone.

In Tremont street near Warrenton street a special construction was made in the roof of the subway to provide for the crossing of the 24-in. pipe.

The cost per linear foot of laying gas-pipes has been as given in the following table:

Size.	No paving.	Paving on gravel.	Paving on concrete base.	Asphalt paving.	In tunnel.	At busy street-crossings.
8-in.	.....	.....	.....	.....	.....	$5 94
12-in.	$2 09	$2 38	$4 09	$4 64	.....	5 80–8 31
18-in.	.....	4 13	6 35			
20-in.	4 34					
24-in.	.....	5 75	7 61	.....	$9 40	
24-in. and 12-in. together,	.....	9 06	.....	.....	11 71	

ELECTRIC CONDUITS.

Edison Electric Illuminating Company.

		Linear feet of duct removed.	Linear feet of duct laid.
SECTION 2.	2½-in.	277	273
" 3.	2½-in.	52	52
" 4.	2½-in.	91.5	92.5
	3-in.	168	170.5

Boston Electric Light Company.

SECTION 4.	3-in. temporary		591
	4-duct conduit	404	
	2-duct conduit	87	

New England Telephone & Telegraph Company.

SECTION 4.	3-inch temporary		146
	3-duct conduit	146	
	2-duct conduit	45	45
	Total	2,906.5	1,415

The approximate cost of sewer and pipe-changes to August 15, 1896, is as follows:

Kind of pipe.	Approximate cost to August 15, 1896.
Sewers	$10,000
Water-pipes	41,000
Gas-pipes	21,000
Total	$72,000

COST OF THE SUBWAY.

Nothing has been discovered so far, either in the work done by contract or in that done by day labor, to indicate that the cost of Sections 1, 2, 3, 4, 5, 6, and 10 — in short, all work on the subway that has thus far been begun — will exceed the Engineer's estimate made early in 1895.

Respectfully submitted,

HOWARD A. CARSON,
Chief Engineer.

REPORT OF THE CHIEF ENGINEER FOR CHARLESTOWN BRIDGE.

BOSTON TRANSIT COMMISSION, CHARLESTOWN BRIDGE,
50 CITY HALL, August 15, 1896.

HON. GEORGE G. CROCKER, *Chairman Boston Transit Commission:*

DEAR SIR: The following is a synopsis of the work done on the Charlestown bridge during the year ending August 14, 1896:

The general plan of the bridge, shown on Plate 47, was prepared for submission to the Harbor and Land Commissioners and to the Secretary of War. It was approved by the former November 25, 1895, and by the latter December 27, 1895.

The total length of the bridge and approaches will be approximately 1,970 feet, of which 1,090 ft. will be over water, and will consist of ten fixed spans of 85 ft. each, with one draw span 240 ft. long. There will be a span over the Fitchburg railroad and one over Water street.

The draw span will be a through span, and all other spans will be deck spans.

There will be two channels through the draw, each 50 ft. wide, and the under side of the draw will be 23 ft. above mean high water.

The width of the bridge throughout will be 100 ft., with two sidewalks, each 10 ft. wide, and a paved roadway 80 ft. wide, except that the roadway of the draw will be of plank.

The grade on the Boston approach to the draw is not to exceed three per cent.; and on the Charlestown approach the grade is to be the same as on the Boston approach. From the Fitchburg railroad to the draw the grade will be about eight-tenths of one per cent.

A system of carefully measured base lines has been established for use in the surveys and during the construction of the bridge.

Street lines and land boundaries have been determined from plans and deeds on file in the Engineering Department of the city of Boston, or recorded in the Suffolk and Middlesex Registries of Deeds, from plans and records in the possession of Thomas Doane, C.E., and from monuments on the ground.

Plans and descriptions of the land required for the bridge have been prepared.

Borings have been made on the lines of the bridge and its approaches; the aggregate depth of the borings being 1,580 ft. Four hundred and twenty-seven samples of the borings have been preserved, and all borings recorded and plotted.

Detail plans for the Charlestown approach to the bridge have been partially prepared, and studies made for the rearrangement of grades of the connecting streets. A general plan of the Charlestown approach is shown on Plate 48.

Plans, specifications, and contract for ten masonry piers were prepared, and bids received on July 21, 1896. The contract was awarded to Perkins & White, the lowest bidders. The first work on this contract, the driving of certain test piles, was begun this day.

The general construction of the piers is shown on Plate 49, Pier 5 being illustrated as showing the maximum dimensions of foundation and masonry. The foundations are of Portland cement concrete, supported on two sets of spruce piles cut off at different grades, the whole being enclosed in a curbing of sheet piling. The concrete to within one foot of its top is deposited under water, and the upper foot of concrete put in place and levelled while the curbing is pumped free of water. The curbing is to be made sufficiently strong to serve as a coffer-dam while constructing the pier from the top of the concrete foundation to about Grade 5, or half tide.

From Grade 5 to high tide the pier will be built by tide work.

The masonry is granite, backed or filled with Portland cement concrete. The curbing will be cut off near the top of the concrete foundation after the pier is completed.

The greatest depth of concrete foundation will be about 26 ft., and the greatest height of masonry in piers will be 30 ft.

Respectfully submitted,

WILLIAM JACKSON,

Chief Engineer Charlestown Bridge.

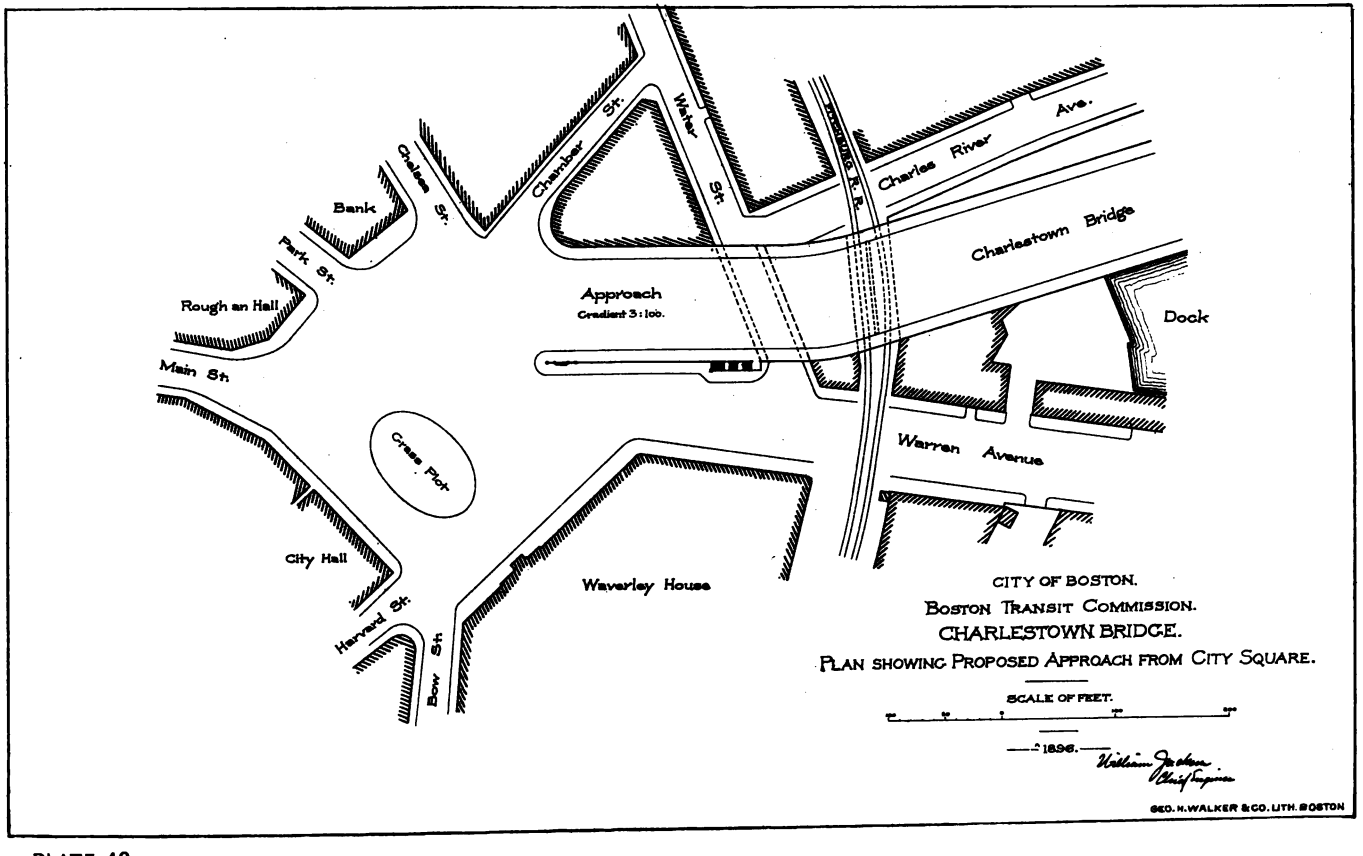

Chelsea St.
Chamber St.
Water St.
Boston & M. R.R.
Charles River Ave.
Bank
Park St.
Rough an Hall
Main St.
Approach
Gradient 3:100.
Charlestown Bridge
Dock
Crass Plot
Warren Avenue
City Hall
Harvard St.
Bow St.
Waverley House
CITY OF BOSTON.
BOSTON TRANSIT COMMISSION.
CHARLESTOWN BRIDGE.
PLAN SHOWING PROPOSED APPROACH FROM CITY SQUARE.
SCALE OF FEET.
1896.
William Jackson
Chief Engineer
GEO. H. WALKER & CO. LITH. BOSTON

PLATE 48.

APPENDIX A.

DECISION OF THE SUPREME COURT ON THE SUIT FOR INJUNCTION.

PRINCE ET AL. *v.* CROCKER ET ALS.

Decision rendered June 15, 1896.

ALLEN, J.

The general complaint of the plaintiffs as stated in their bill is, that if the Transit Commissioners are permitted to proceed in the execution of the enterprise committed to them by St. 1894, c. 548, they will involve the city of Boston in an indebtedness or liability of many millions of dollars beyond the limit of indebtedness prescribed by the laws of the Commonwealth, and will do this without the authority of the City Council, or of the consent of the tax-paying citizens; and also that this statute would have the effect to deprive the city of many rights and privileges belonging to its inhabitants, and especially that it would infringe rights which relate to the control of the streets and highways of the city by the Aldermen and Street Commissioners; all in violation of the right of the inhabitants of the city to govern themselves.

It is provided by § 40 of the statute that the Transit Commission shall not "take any land or commence the construction of any subway or tunnel until this act shall be accepted by a majority of the voters of said city, voting at some special election called by the Mayor. In the printed copy of the Subway Legislation furnished to us by mutual consent of counsel, it is stated that this act was accepted at a special election, held July 24, 1894. There is no averment in the bill that no such vote of acceptance had been passed, and though the briefs on both sides say little or nothing on this point, yet it is implied in the briefs furnished by one of the counsel for the plaintiffs (Mr. Bryant) that there had been such an acceptance; and it is then contended that the people at the polls are not the tribunal to determine what debts shall be incurred by or in behalf of the city, because, by a law which stands unrepealed, that question is to be determined by both branches of the city government, and a two-thirds vote of each branch is required to authorize the incurring of a debt by the city. As the fact of the acceptance of the statute has significance in certain aspects of the questions presented, we will state at the outset that, in the absence of any averment to the contrary, we assume that such a vote of acceptance was duly passed. This is a fact of which the Court should take judicial notice. Andrews *v.* Knox Co., 70 Ill. 65; State *v.* Swift, 69 Ind. 505; Ranch *v.* Com., 78 Penn. St. 490. Moreover, it is very doubtful, to say the least, whether the plaintiffs, as tax-paying inhabitants, have any standing to maintain the bill in their own names, except upon the assumption that the vote to accept the statute is virtually a vote to raise or to pay money, within the meaning of Pub. Sts. c. 27, § 129. In this Commonwealth, contrary to what has been held in some other jurisdictions, a suit like the present has been considered not to fall within the general jurisdiction of a court of equity. Baldwin *v.* Wilbraham, 140 Mass. 459; Steele *v.* Municipal Signal Co., 160 Mass. 36; Carlton *v.* Salem, 103 Mass. 141. By Pub. Sts. c. 27, § 129, when a

town votes to raise by taxation or pledge of its credit, or to pay from its treasury, any money for a purpose other than those for which it has the legal right and power, it may be restrained by this Court upon the suit or petition of not less than ten taxable inhabitants. The case of Frost *v.* Belmont, 6 Allen, 152, was brought under St. 1847, c. 37, which was like Pub. Sts. c. 27, § 129.

The case of Lowell *v.* Boston, 111 Mass. 504, was also brought under the similar provision found in Gen. Sts. c. 18, § 79. No point was there made that under the statute the petitioners had no right to be heard.

It is contended, however, by the present defendants that the plaintiffs have no standing to maintain this bill, but in favor of affording a remedy against a use of public money which is supposed to be illegal we think a somewhat liberal construction should be given, and that the vote to accept the statute is sufficient to give the plaintiffs a standing in court under Pub. Sts. c. 27, § 129.

The two principal grounds upon which the plaintiffs contend that St. 1894, c. 548, as a whole is invalid are that it imposes a heavy debt upon the city and to a certain extent takes away from the city the control of its streets. The plaintiffs deny the power of the Legislature to do either of these things without the authority of the City Council or the consent of the tax-paying citizens of the city. It has, however, been established by a great weight of usage and authority that the Legislature may impose such a duty and burden upon towns and cities without their own consent. We do not deem it necessary to go into an extended discussion of this subject, or to consider what objects may be so special or local in their character as not to come within the general rule. As to roads of all kinds, and bridges and sewers, the doctrine is well established in this Commonwealth and elsewhere that the Legislature may prescribe what shall be done, and require cities and towns to bear the expense to such an extent and in such due proportions as it may determine. The powers which had been given to cities and towns by the Legislature by special or by general laws are in no sense a contract and do not become vested rights as against the Legislature. Coolidge *v.* Brookline, 114 Mass. 592, 596, 597; Agawam *v.* Hampden, 130 Mass. 528, 530; Kingman, Petitioner, 153 Mass. 566, 573–576; People *v.* Morris, 13 Wend. 225; Sloan *v.* State, 8 Blackf. 361; People *v.* Flagg, 46 N.Y. 401; Phila. *v.* Field, 58 Penn. St. 320; Pumphrey *v.* Baltimore, 47 Md. 145; Dillon Mun. Corp. (4th ed.), §§ 54, 73, 74, 831, and other cases there cited.

If this power were otherwise doubtful, in the present case the statute under consideration is not peremptory and absolute, but it remained inoperative until accepted by a majority of the voters of the city. The plaintiffs contend that the statute is to become operative without the authority of the City Council or the consent of the tax-paying citizens; but if a consent were necessary we know of no authority or legal reason for requiring any other consent than that of qualified voters. In Merrick *v.* Amherst, 12 Allen, 500, 506, the Court, while intimating that no consent at all was necessary, said: "To guard against all danger of mistake, and to obtain the highest evidence from those most interested that the imposition of the tax was not unequal or disproportionate to the expected benefits, the Legislature required that it should not be laid on the inhabitants of the town unless two-thirds of the voters at a meeting to be called for the purpose should assent to its imposition." The instances where legislatures have provided that towns or cities or counties might or should bear the whole or a portion of the expense of local improvements in case the qualified voters should assent, and not otherwise, are numberless. In our own statutes from early times, such legislation has been common. In the Public Statutes now in force, many instances are found enacting that cities and towns may by vote accept the provisions of certain statutes, and thereupon

shall be subject to certain duties and burdens. There have been many special laws to the same effect. It cannot be necessary to cite more than a few illustrative instances. Pub. Sts. c. 27, §§ 10–13, 27, 29, 44, 65, 69, 74; c. 28, §§ 3, 22, 23; c. 35, § 4; c. 45, §§ 44, 52; c. 50, §§ 20, 22, 25; c. 51, § 10; c. 80, §§ 8–13. By the second amendment to the Constitution, city governments cannot be established except with the consent and on the application of a majority of the inhabitants of the town present and voting thereon at a meeting. All of the cities of the Commonwealth have been incorporated under this amendment. Larcom *v.* Olin, 160 Mass. 102, 104, 108. When the Legislature imposes such a condition in order to bind a city or town or county to assume a particular burden, it must be complied with; but an assent by vote will give full effect to the statute, and the city, town, or county will thereupon become bound. Hampshire *v.* Franklin, 16 Mass. 76, 87, 90; Stone *v.* Charlestown, 114 Mass. 214; Central Bridge Corp. *v.* Lowell, 15 Gray, 106, 116; St. Joseph *v.* Rogers, 16 Wall. 644, 662, 663; Knox Co. *v.* Aspinwall, 21 How. 539; Dillon Mun. Corp. §§ 44, 519, 526, 551–553, and cases there cited. It is not material that the work is not put in charge of the Street Commissioners of the city. The Legislature might provide for doing the work at the expense of the city, but through other agents than those regularly appointed by the city; it might impose liability on the city, incur the expense, and require payment by the city. The acceptance of the act by the city precludes objection on this score, even if such objection would otherwise have been open.

The foregoing considerations apply to the bridge over Charles river provided for in § 30, as well as to the subway itself.

It is further contended that taxation can only be for a public use; that the term "public use" in reference to taxation has a more restricted meaning than when applied to the taking of land by eminent domain; that the subway will not be a highway, or open and free to be used by the public for driving or walking; that when finished the statute authorizes the Transit Commission virtually to grant a lease of it to any street-railway company for fifty years; and that the use of the subway which is contemplated is not a public use.

That the Legislature can authorize a city or town to tax its inhabitants only for public purposes is well settled and familiar. Opinion of Justices, 155 Mass. 598, 601, and cases there cited. But railroads are always held to be built for public use, whether the right to take land or the right to grant pecuniary aid to them is considered. The Legislature of this Commonwealth has granted aid to railroad corporations from its own treasury. See instances cited in 153 Mass. 570. It has also in a number of instances authorized cities and towns to furnish such aid by subscribing to stock or otherwise. For illustrations see Sts. 1852, c. 156; 1855, cc. 394, 395; 1860, cc. 34, 184; 1861, c. 98; 1862, cc. 56, 78; 1863, cc. 96, 104, 105; 1864, cc. 11, 242, 245, 246, 249, 260. Finally such municipal aid was authorized by general laws. Sts. 1870, c. 325, § 3; 1874, c. 372, § 35; Pub. Sts. c. 112, § 46. The constitutionality of such legislation has not been brought into direct controversy before this Court, but indirectly it has been recognized. Kittredge *v.* North Brookfield, 138 Mass. 286; Com. *v.* Williamstown, 156 Mass. 70. And elsewhere it has been established by such a weight of judicial authority that we regard it as settled. Olcott *v.* Supervisors, 16 Wall. 678, 694–696; Railroad *v.* Otoe Co., 16 Wall. 667; Pine Grove *v.* Talcott, 19 Wall. 666; Dillon Mun. Corp. (4th ed.), §§ 153–158, 508. The building of the subway for the carriage of such passengers as pay the regular fare is therefore for a public use; and it is within the constitutional power of the Legislature to order or sanction taxation for it.

The plaintiffs also contend that the statute is in violation of the fourteenth amendment to the Constitution of the United States. This

objection is not dwelt upon in argument, and it is enough to say that we think it is unfounded.

The plaintiffs further contend that the statute is unconstitutional because it omits to provide for compensation for property taken or injured, and especially for taking part of the Common and Public Garden. But the plaintiffs cannot be heard to object to the constitutionality of the statute on grounds which only affect others than themselves. Hingham & Quincy Bridge *v.* Norfolk, 6 Allen, 353; Davis *v.* County Commissioners, 153 Mass. 218, 228. So far as other private owners are concerned, the plaintiffs do not represent them and have no standing to be heard in their behalf.

In respect to the matter of providing compensation the stress of the argument of the plaintiffs rests on the contention that there is no provision for compensation for so much of the Common and Public Garden as may be taken. It is urged that these were dedicated to the use and enjoyment of the inhabitants of the town long before the city charter was granted, and that they are held by the city in trust to secure and promote such use; that the city as trustee for these purposes is entitled to compensation if any part of either is taken; and that the fact that the city is the party to pay, as well as to receive, does not affect this argument, because the city acts in two different capacities.

If we assume that the plaintiffs are entitled to be heard on this branch of the argument, it is well settled that land already appropriated to one public use may be taken by authority or direction of the Legislature for another public use. Old Colony Railroad *v.* Framingham Water Co., 153 Mass. 561. We do not need to go into any nice consideration of the precise capacity, interest, or duty of the city on caring for the Common or Public Garden, because both the Legislature and the city have consented to such new use of both as may be included within the terms of the statute. If the right to their use is in the inhabitants of the city, their vote accepting the act binds them. If it is in the public at large, as distinguished from the inhabitants of the city, the interests of the public are under the protection of the Legislature. The plaintiffs in their capacity of tax-paying citizens of Boston, or as voters, or as a constituted part of the public at large, can assert no right to the continued use of the Common or of the Public Garden as public parks, or to have compensation paid for the surrender of such use, against the combined action of the Legislature in passing the statute, and of the inhabitants of the city in accepting it. Brooklyn Park Commrs. *v.* Armstrong, 45 N.Y. 234; Dillon Mun. Corp. (4th ed.), §§ 598 n., 650, 651, 651a, and cases there cited. Under these circumstances we need not pursue the questions relating to the title to and interest of the public in public parks — questions somewhat discussed in Abbot *v.* Cottage City, 143 Mass. 521, and Attorney-General *v.* Abbot, 154 Mass. 323.

It is also contended by the plaintiffs that if St. 1894, c. 548, bears such a construction as to allow the Transit Commission to enter the Public Garden with the subway, the statute is unconstitutional because it impairs the obligation of a contract between the Commonwealth and the city. This supposed contract is found in St. 1859, c. 210, § 3, which provided that the commissioners on the Back Bay should fill up and complete at the expense of the Commonwealth so much of Arlington street as remained to be completed, and the strip of land easterly of said street, which had theretofore been released by the Commonwealth to the city, and further that "no building shall hereafter be erected between Arlington and Charles streets, except such as are expedient for horticultural purposes." It is argued that this is a contract that the Commonwealth would not erect a building there, and that the subway as constructed is a building, and if it is authorized by St. 1894, c. 548, then that the statute is a violation of said contract. The short answer to this argument is that the inhabitants of the city have accepted

St. 1894, c. 548, and so have consented to whatever is contained therein. Contracts may be waived by the parties to them. If this was a contract, the city was a party to it and might waive it.

The plaintiffs also contend that the statute is invalid because work to be done under it will increase the debt of the city much beyond the limit of municipal indebtedness fixed by St. 1885, c. 178, § 2. But the same authority which fixed that limit may change it; and § 37, which requires the treasurer of the city to issue bonds, also provides that this debt shall not be included in determining the limit of indebtedness. Similar exceptions have been very numerous in the legislation of the last ten years. See Blue Book for 1895, p. 805. There is no averment in the bill that the limit of indebtedness as thus extended will be exceeded by the issue of the bonds provided for by St. 1894, c. 548.

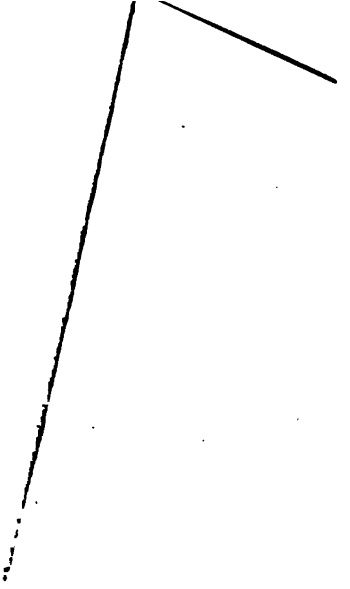
It is also argued by the plaintiffs that the statute does not authorize any entry upon the Public Garden, that at any rate it does not authorize the erection of a building thereon, and that the subway as constructed there is a building, which is in violation of Pub. Sts. c. 54, §§ 16, 17.

In determining whether an entry upon the Public Garden is authorized, the Court will take notice of the situation of the streets and squares and public grounds. The Boylston-street mall upon the southerly side of the Common extends westerly along the line of Boylston street from Tremont street to Charles street, which last-named street separates the Common from the Public Garden, and Park square is a space open for travel south of Boylston street and bounding thereon, and is in part opposite to the southerly end of Charles street, where it joins Boylston street at right angles. Columbus avenue opens into Park square from the south west.

The St. of 1894, c. 548, § 25, authorizes the Transit Commission to construct a subway or subways of sufficient size for four railway tracks, with approaches, entrances, sidings, stations, and connections therefor, and for the running of railway cars thereon, through and under Tremont street and the adjoining mall of Boston Common, etc. Section 27 authorizes the Commission also to "construct subways to be used for the same purposes as said other subways, but which may be made of sufficient width for two tracks only, as follows: From Tremont street through and under Boylston street and the adjoining mall of Boston Common, or other public or private lands adjoining said street, to a point on or near Boylston street, where a suitable connection with surface tracks may be made; from Boylston street through and under Park square and Columbus avenue, or other lands adjoining said square and avenue, to a point on or near Columbus avenue, where a suitable connection with surface tracks may be made; and from Tremont street through and under Park street," etc. Section 29 provides that "Said commission may locate and construct said subways, tunnels, approaches, tracks, sidings, stations, entrances, and connections where it deems best within the limits aforesaid, . . . but shall not permanently occupy above the surface of the ground for any purpose any part of said Common, except so much of the Tremont and Boylston street malls as may be necessary for stairways to stations and coverings therefor." Section 35 provides that "Said Commission may, on or before the completion of said subways and tunnels, grant locations for tracks, . . . shall order all surface tracks to be removed . . . from Boylston street, between Park square and Tremont street." By St. 1895, c. 440, § 3, it is provided that "No portion of the Common, with the exception of the malls on Boylston and Tremont streets, shall be permanently occupied above the surface of the ground for any of the purposes of the subway, except so far as necessary for the suitable ventilation thereof, and no portion of said malls shall be permanently occupied above the surface of the ground except so far as necessary for

The work actually done by the Commissioners in the Public Garden perhaps indicated an intention on their part, not of reaching the surface tracks on Boylston street by the nearest practicable approach to the subway as it was built under Charles street, but of deflecting the surface tracks on Boylston street at its junction with Arlington street to the southwesterly side of the Garden, and of laying tracks over the surface of the Garden until they reached the incline of the subway in the Garden. But such intention, if it ever existed, it seems has been abandoned.

The opinion of the Court justifies the construction of the subway in the Public Garden on the ground that it was necessary in order to comply with the provisions of § 29 of the St. of 1894 and § 3 of the St. of 1895, to the effect that no part "above the surface" of the Common should be occupied by railway tracks or for any other purpose than for suitable ventilation, for shelter and stairways to stations, and for coverings therefor, and not on the ground that authority was given by the statutes to the Commissioners to use the Garden in any such manner as they saw fit for the purpose of constructing the subways. Without laying much stress upon the employment of the word "tunnel" in the statutes as distinguished from "subway," the use of an incline beneath the surface of the ground for tracks to reach a subway or tunnel is not, I think, an occupation "above the surface," within the meaning of the provisions of the statutes which have been cited. An incline is a necessary part of the subway, and is to be included within the limits of the subway. The phrase "other public or private lands adjoining said street," found in § 27 of the St. of 1894, is found in other sections of the statute, and cannot be held to extend the termini of the subways as fixed by other provisions of the statutes. The phrase means that within the authorized termini the Commissioners may construct the subways in the directions indicated through the land, whether the land be public or private. I do not dissent from the result reached by the Court because the subway had been substantially constructed in the Public Garden without any objection so far as appears on the part either of the Commonwealth or of the city of Boston; and I should not feel justified under such circumstances in attempting to undo the work there done because I differed in opinion with the Commissioners upon the construction to be given to the statutes unless the construction acted on by them seemed to me impossible; but my opinion is that the statutes were not intended to authorize such a use as they have made of the Public Garden.



APPENDIX C.

BOSTON TRANSIT COMMISSION. — CANVASS OF BIDS FOR STEEL, SECTION 2, SUBWAY, SEPTEMBER 12, 1895.

BIDDERS AND ADDRESSES.	Number of tons.	Price per ton.	Totals.
The King Bridge Company, Cleveland, O.	1,200	$64 50	$77,400 00
Passaic Rolling Mill Company, Paterson, N.J.	1,200	61 00	73,200 00
The Carnegie Steel Company, Limited, 125 Milk street, Boston, Mass.	1,200	60 00	72,000 00
A. & P. Roberts Company, Pencoyd Iron Works, Philadelphia, Pa.	1,200	59 55	71,460 00
Edge Moor Bridge Works, Wilmington, Del.	1,200	58 75	70,500 00
Pennsylvania Steel Company, Steelton, Pa.	1,200	58 70	70,440 00

APPENDIX D.

BOSTON TRANSIT COMMISSION. — CANVASS OF BIDS FOR STEEL, SECTION 3, SUBWAY, OCTOBER 24, 1895.

BIDDERS AND ADDRESSES.	Number of tons.	Price per ton.	Totals.
Edge Moor Bridge Works, Wilmington, Del.	1,250	$57 60	$72,000 00
Page, Newell & Co., Boston, Mass.	1,250	52 00	65,000 00
Passaic Rolling Mill Company, Paterson, N.J.	1,250	51 90	64,875 00
New Jersey Steel and Iron Company, Trenton, N.J. . . .	1,250	51 70	64,625 00
Pennsylvania Steel Company, Steelton, Pa.	1,250	49 88	62,358 00

APPENDIX G.

BOSTON TRANSIT COMMISSION. — CANVASS OF BIDS FOR STEEL, SECTION 4, SUBWAY, MARCH 12, 1896.

BIDDERS AND ADDRESSES.	232 tons beams and rods.	315 tons beams, posts, girders, etc.	Totals.
	a	*b*	
Edge Moor Bridge Works,	$47 00	$52 00	$27,284 00
Wilmington, Del.	10,904 00	16,380 00	
Pennsylvania Steel Co.,	45 88	51 88	26,986 36
Steelton, Pa.	10,644 16	16,342 20	
A. & P. Roberts Co.,	50 20	46 00	26,136 40
Pencoyd Iron Works, Phila.	11,646 40	14,490 00	
Passaic Rolling Mill Co.,	45 60	49 00	26,014 20
Paterson, N.J.	10,579 20	15,435 00	
New Jersey Steel & Iron Co.,	48 00	44 60	25,185 00
Trenton, N.J.	11,136 00	14,049 00	

APPENDIX H.

BOSTON TRANSIT COMMISSION. — CANVASS OF BIDS FOR STEEL, SECTION 5, SUBWAY, AUGUST 13, 1896.

BIDDERS AND ADDRESSES.	80 tons steel.	Totals.
Carnegie Steel Company, Limited, Pittsburgh, Pa...	$68 88	$5,510 40
New Jersey Steel & Iron Company, Trenton, N.J...	64 77	5,181 60
Pennsylvania Steel Company, Philadelphia, Pa.....	54 80	4,384 00
Boston Bridge Works, Boston, Mass.....	51 80	4,144 00

APPENDIX I.

BOSTON TRANSIT COMMISSION. — CANVASS OF BIDS FOR STEEL, SECTION 6, SUBWAY, APRIL 30, 1896.

BIDDERS AND ADDRESSES.	110 tons rods, nuts, etc.	15 tons plain I-beams.	Totals.
	a	*b*	
Geo. T. McLaughlin & Company, 120 Fulton St.	$109 60 12,056 00	$36 00 540 00	$12,596 00
Passaic Rolling Mill Company, Paterson, N.J.	90 50 9,955 00	35 00 525 00	10,480 00
New Jersey Steel & Iron Company, Trenton, N.J.	80 80 8,888 00	35 00 525 00	9,413 00
W. E. Clark, 8 Oliver St.	78 00 8,580 00	35 00 525 00	9,105 00
Harrington, Robinson & Company, 125 Milk St.	78 00 8,580 00	34 00 510 00	9,090 00
Edge Moor Bridge Works, Wilmington, Del.	77 00 8,470 00	38 00 570 00	9,040 00
Carnegie Steel Company, Pittsburgh, Pa.	76 66 8,432 60	34 50 517 50	8,950 10
King Bridge Company, Cleveland, O.	64 00 7,040 00	54 00 810 00	7,850 00
Pennsylvania Steel Company, Steelton, Pa.	65 80 7,238 00	34 80 522 00	7,760 00
Page, Newell & Company, 139 Milk St.	63 50 6,985 00	37 50 562 50	7,547 50
Berlin Iron Bridge Company, E. Berlin, Conn.	50 00 5,500 00	36 00 540 00	6,040 00

APPENDIX J.

BOSTON TRANSIT COMMISSION.—CANVASS OF BIDS, SECTION 6, SUBWAY, MAY 7, 1896.

BIDDERS AND ADDRESSES.	28,000 cu. yds. earth excavation.	125 tons steel and iron work, setting and securing.	100 cu. yds. brick masonry, Am. cement.	2,600 cu. yds. brick masonry, Port. cement.	8,100 cu. yds. concrete masonry, Port. cement.	TOTALS.
	a	*d*	*e*	*ee*	*ff*	
Metropolitan Construction Co., Boston, Mass.	$11 50 322,000 00	$10 00 1,250 00	$13 75 1,375 00	$16 50 42,900 00	$9 50 76,950 00	$444,475 00
Steward & McDermott, New York.	8 00 224,000 00	15 00 1,875 00	15 00 1,500 00	16 50 42,900 00	9 00 72,900 00	343,175 00
Grace & Hyde Co., Chicago, Ill.	7 75 217,000 00	20 00 2,500 00	14 00 1,400 00	16 00 41,600 00	9 50 76,950 00	339,450 00
Frederick E. Shaw, Providence, R.I.	7 45 208,600 00	20 00 2,500 00	14 00 1,400 00	18 00 46,800 00	9 00 72,900 00	332,200 00
Blagen & Bush, Boston, Mass.	6 00 168,000 00	20 00 2,500 00	16 00 1,600 00	17 00 44,200 00	11 50 93,150 00	309,450 00
Wilmarth, Haskin & Murphy, Boston, Mass.	6 00 168,000 00	15 00 1,875 00	14 50 1,450 00	16 00 41,600 00	9 50 76,950 00	289,875 00
E. W. Everson, Providence, R.I.	5 60 156,800 00	15 00 1,875 00	15 00 1,500 00	18 00 46,800 00	10 00 81,000 00	287,975 00
Shailer-Schniglau Co., Chicago, Ill.	4 50 126,000 00	12 00 1,500 00	15 50 1,550 00	15 50 40,300 00	8 25 66,825 00	236,175 00
Jones & Meehan, Jamaica Pl., Boston, Mass.	3 75 105,000 00	8 00 1,000 00	15 00 1,500 00	16 00 41,600 00	9 00 72,900 00	222,000 00
R. A. Malone & Co., Boston, Mass.	3 75 105,000 00	12 00 1,500 00	13 00 1,300 00	15 00 39,000 00	8 00 64,800 00	211,600 00

APPENDIX K.

BOSTON TRANSIT COMMISSION. — CANVASS OF BIDS FOR STEEL, SECTION 10, SUBWAY, AUGUST 6, 1896.

BIDDERS AND ADDRESSES.	690 tons steel.	Totals.
Pennsylvania Steel Co., Philadelphia, Pa.	$60 00	$41,400 00
Edge Moor Bridge Works, Wilmington, Del.	53 83	40,592 70
Passaic Rolling Mill Co., Paterson, N.J.	51 80	35,742 00
New Jersey Steel and Iron Co., Trenton, N.J.	51 42	35,479 80
Marshall Foundry and Cons. Co., Pittsburgh, Pa.	49 48	34,141 20
A. & P. Roberts Co., Philadelphia, Pa.	44 40	30,636 00
Carnegie Steel Co., Ltd., Pittsburgh, Pa.	42 20	29,118 00

APPENDIX L.

APPROXIMATE STATEMENT OF LENGTHS OF DIFFERENT PORTIONS OF THE SUBWAY.

Section 1.	Incline,	318	feet,	2	tracks,	equal	636	feet	single track.
" 1.	2-track,	685	"	2	"	"	1,370	"	" "
" 1.	4-track,	410	"	4	"	"	1,640	"	" "
" 2.		820	"	4	"	"	3,280	"	" "
" 3.		655	"	4	"	"	2,620	"	" "
" 3½.		30	"	2	"	"	60	"	" "
" 4.		900	"	2	"	"	1,800	"	" "
" 4.		275	"	4	"	"	1,100	"	" "
" 5.		210	"	4	"	"	840	"	" "
" 6.		1,085	"	2	"	"	2,170	"	" "
From Sect. 6 to Sect. 8,		570	"	2	"	"	1,140	"	" "
Section 8,		495	"	2	"	"	990	"	" "
From Section 8 to Washington street,		70	"	2	"	"	140	"	" "
From Court street to Adams sq. in Cornhill,		550	"	2	"	"	1,100	"	" "
From Cornhill to Hanover street in Washington street,		580	"	3	"	"	1,740	"	" "
From Hanover street to Section 10 in Washington street,		60	"	4	"	"	240	"	" "
Section 10,		665	"	4	"	"	2,660	"	" "
From Section 10 to Travers street,		580	"	4	"	"	2,320	"	" "
From Travers street to Causeway street,		540	"	4	"	"	2,160	"	" "
		9,498 feet = 1.8 miles.					28,006 feet single track = 5.3 miles.		

UNDER CONTRACT OR COMPLETED, AUGUST 15, 1896.

Section 1.	3,646 feet single track;	completed.	
" 2.	3,280 " " "	under contract.	
" 3.	2,620 " " "	" "	
" 3½.	60 " " "	completed.	
" 4.	2,900 " " "	under contract.	
" 5.	840 " " "	" "	
" 6.	2,170 " " "	" "	

15,516 feet = 2.94 miles.

Per cent. of single track under contract or completed, 55.4.

DATE DUE

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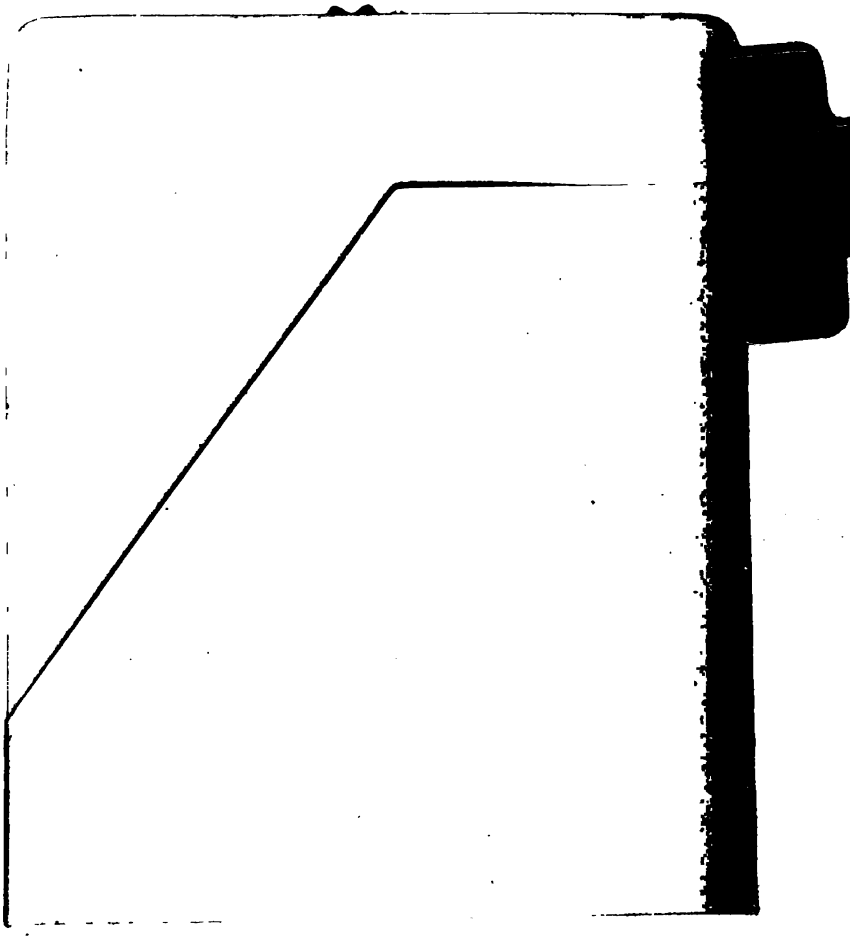
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